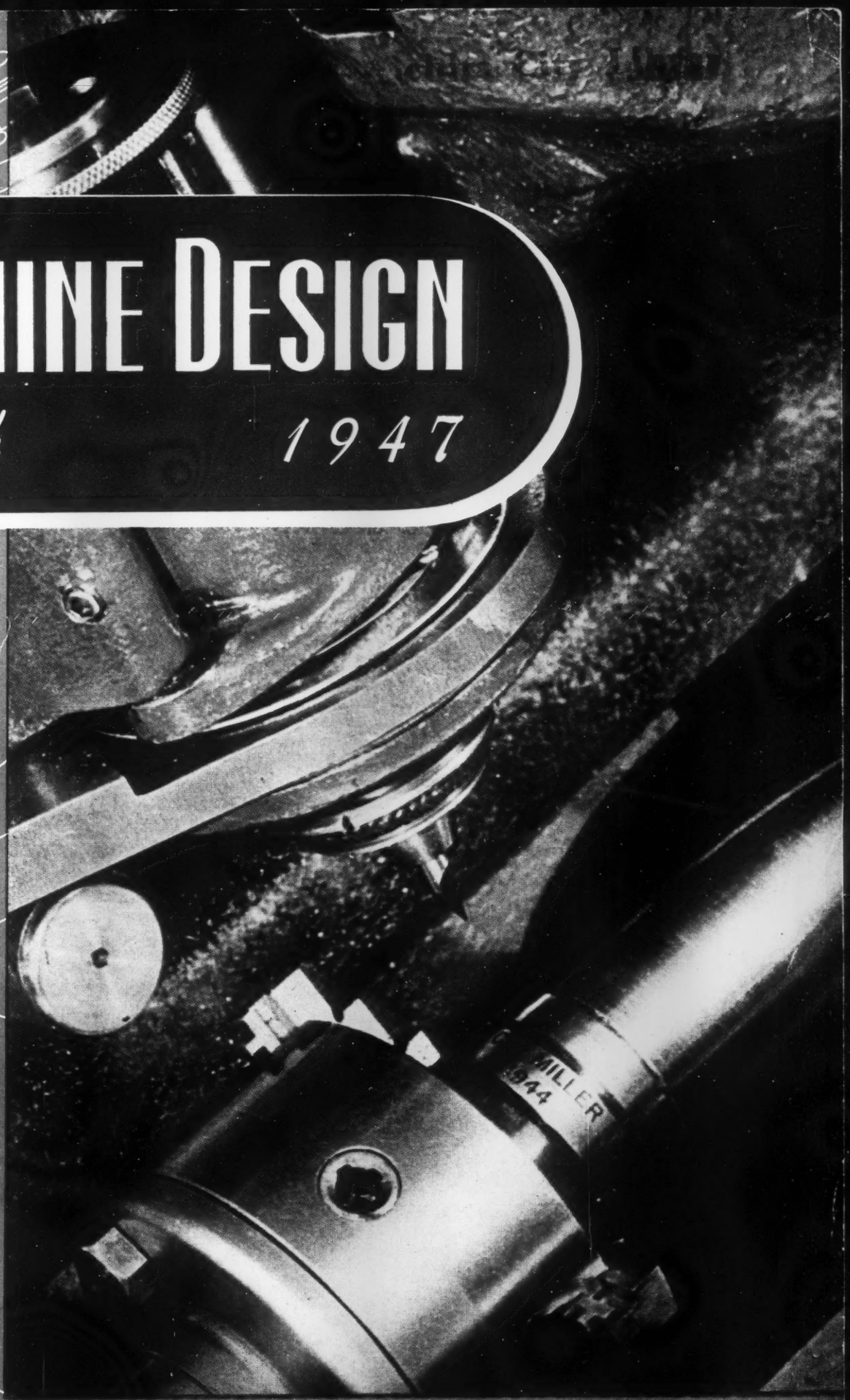
Mar. 47

# MACHINE DESIGN

March 1947

White City Library



*In This Issue:* CYCLIC VARIATIONS IN SPEED
SELENIUM RECTIFIERS . . . DRAWING CHANGE SYSTEM

# Sheave to Transmit 1400 Horsepower...

## ...or a Belt for a 1/4 hp Compressor!

CALL ON THE TEXROPE LINE for the *best* in V-belt engineering and V-belt equipment. That has been true for 22 years — ever since Allis-Chalmers originated the Multiple V-belt drive for industry.

Back of every *Texrope* installation — from fractional horse power V-belts that manufacturers put on washers, air-compressors or water systems—to the biggest V-belt drives ever designed and successfully applied—stands the finest V-belt engineering talent in the world.

There's no substitute for this vast experience and tremendous fund of knowledge. It is reflected in every *Texrope* product.

What do *you* need . . . a few V-belts and sheaves — or a daring new application of the multiple V-belt principle? Call on the *Texrope* line! Equipment and engineering help are as close as your nearest A-C sales office or dealer. ALLIS-CHALMERS, MILWAUKEE.

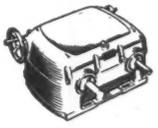
A 2187

## TEXROPE .. Greatest Name in V-Belt Drives

**"Super 7" V-BELTS**
Five Types — Sizes to suit every power transmission job.

**Texsteel, Texdrive, "Magic-Grip"**
— sheaves in a full range of sizes, grooves.

**"Vari-Pitch" SHEAVES**
Exact variations in speed, stationery or motion control.



**SPEED CHANGERS**
Speed variations up to 375% at the turn of a crank.

**ENGINEERING**
Finest V-Belt engineering talent in the world—at your call.

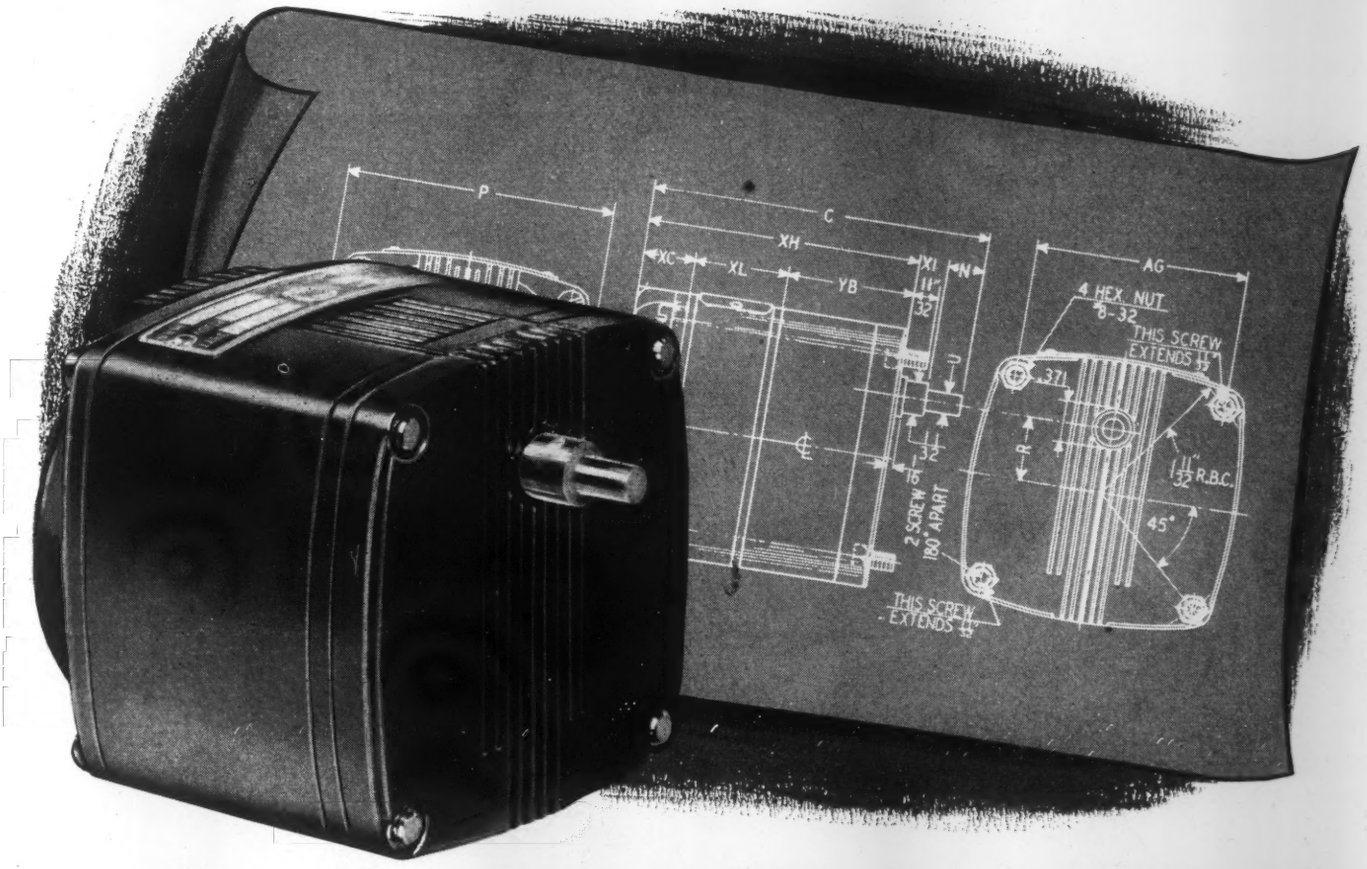
---

TEXROPE "Super 7" V-Belts result from the cooperative research of two great companies — Allis-Chalmers and B. F. Goodrich. They are sold only by A-C.

# ALLIS-CHALMERS

**One of the Big 3 in Electric Power Equipment — Biggest of All in Range of Industrial Products**

1847 1947
A CENTURY OF SERVICE to Industry THAT MADE America Great




# *Motors that* SOLVE DESIGN PROBLEMS

If your design problem is that of finding a small, precise reducer-motor to operate a timer, chart, signal, or other device, here's a unit that can help you. Approximately 2⅜ in. in each dimension, it includes a reducer with a speed as low as one rpm, and is available in either synchronous or nonsynchronous types.

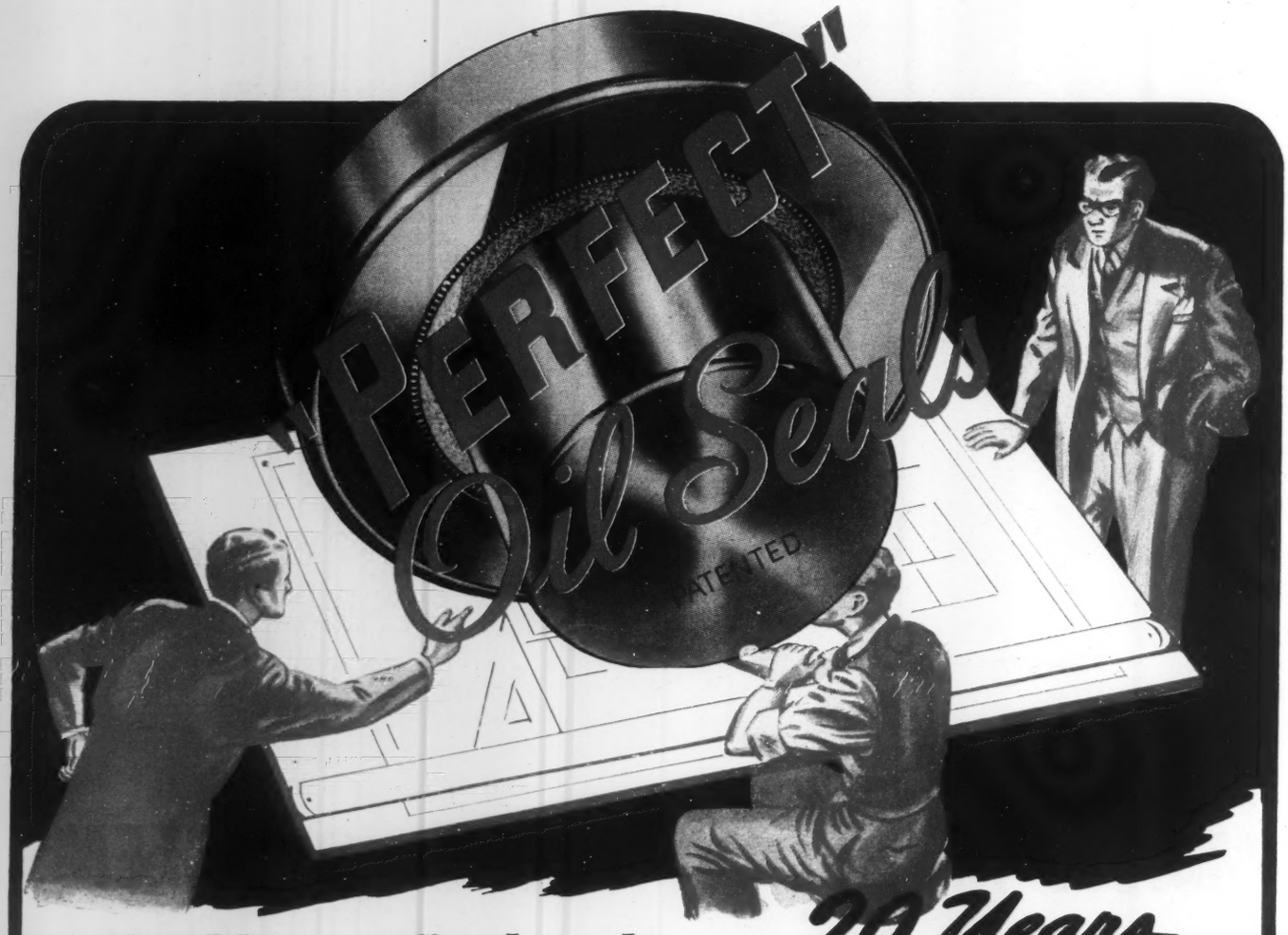
All Bodine motors are carefully manufactured to high precision standards. Their compact design makes them fit easily into all types of instruments and machines where space is at a premium, and their precision-type construction assures continued, long operation, even under adverse circumstances of temperature or lubrication.

If your design requires operation by a fractional horsepower motor, with or without speed reducer, ask Bodine engineers to suggest the right motor for your needs. Bodine's long experience with motor applications can help you. Bodine Electric Co., 2258 West Ohio Street, Chicago 12, Illinois.

## *TYPICAL APPLICATION*

Eagle Signal Corporation's Two-Dial "EA" Synchronous Controller has two independent dials, each of which has its own total time cycle adjustments, as well as independent setting for intervals in the cycle. A Bodine motor provides reliable operation for the traffic lights it controls.

# BODINE *FRACTIONAL HORSEPOWER MOTORS*




# Could you afford to devote 20 Years

## TO THE SOLUTION OF JUST ONE PHASE OF A MACHINE DESIGN PROBLEM?

Since the days of James Watt, machine designers have dealt with the problem of sealing shafts and mechanisms.

As design problems go, it doesn't appear to be too complicated, but its proper solution may determine to a great extent the effectiveness and service life of the mechanism.

For the past 20 years, Chicago Rawhide Engineers have concentrated on this problem. In all, more than 400 man years of effort have been devoted to its many phases, on the board and in the field. A lot has been learned in those years.

Why not take advantage of this vast accumulation of data and experience when designing your equipment and concentrate your own creative skill on other problems which have not been so satisfactorily solved.

2530

**CHICAGO RAWHIDE MANUFACTURING COMPANY**

**1304 ELSTON AVENUE • CHICAGO 22, ILLINOIS**

PHILADELPHIA • CLEVELAND • NEW YORK • DETROIT • BOSTON • PITTSBURGH • CINCINNATI

*67 YEARS MANUFACTURING QUALITY MECHANICAL LEATHER GOODS EXCLUSIVELY AND NOW SIRVENE SYNTHETIC PRODUCTS*

# MACHINE DESIGN

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS



EDITORIAL STAFF

Laurence E. Jermy, Editor

John W. Greve, Managing Editor

Associate Editors

Colin Carmichael  Richard K. Lotz

Roger W. Bolz

Assistant Editors

Harry Raech Jr.  H. N. Goga

Frank H. Burgess, Art Editor

*New York*....B. K. Price, L. E. Browne
*Chicago*.....Erle F. Ross
*Pittsburgh*.....J. C. Sullivan
*Detroit*.....A. H. Allen
*Washington*.....L. M. Lamm
*London*.....Vincent Delport

BUSINESS STAFF

G. O. Hays, Business Manager

Mary L. Callahan, Advertising Service
*Chicago*.....H. H. Dreyer, Manager
M. H. Hall, Ass't. Manager
*New York*.....R. H. Smith, Manager
E. S. Lawson, Ass't. Manager
*Cleveland*.....H. B. Veith, Manager
*Los Angeles*.....F. J. Fuller, Manager

CIRCULATION & RESEARCH

J. W. Zuber, Director
Jack C. Gernhard, Readers Service
R. L. Hartford, Market Research
J. G. Doolittle, Field Representative



MAIN OFFICE

Penton Building, Cleveland 13, Ohio

BRANCH OFFICES

*New York 17*.....16 East 43rd St.
*Chicago 11*.... 520 North Michigan Ave.
*Pittsburgh 19*....2800 Koppers Building
*Detroit 2*.....6560 Cass Ave.
*Washington 4*...956 National Press Bldg.
*Los Angeles 4* 130 N. New Hampshire Ave.
*London, S.W.1* 2 Caxton St., Westminster

Published by The Penton Publishing Co. E L. Shaner, Pres. and Treas.; G. O. Hays, Vice Pres. and Gen. Mgr.; R. C. Jaenke, Vice Pres.; F. G. Steinebach, Vice Pres. and Secy.; E. L. Werner, Asst. Treas. Published on the seventh of each month.

**THIS MONTH'S COVER: Roll attachment on Gorton engraver makes engraving on cylindrical workpieces as simple as on flat pieces. Features of the attachment and its linkages to the pantograph machine are discussed on Page 141.**

# CONTENTS


March, 1947  Vol. 19, Number 3



Drawing-Change System—facilitates processing throughout plant ..... 101
*By A. C. Wedge*

Scanning the Field for Ideas ..... 105

Cyclic Variations in Speed—obtainable from cycloidal cranks ..... 108
*By E. H. Schmidt*

Selenium Rectifiers—improvements broaden field of application ..... 112
*By Julian Lobenstein*

Practical Design of Rubber Parts ..... 115
*By Edward E. Blaurock*

Electronics Aids Hydraulic Circuit Analysis ..... 121

Production Processes—XXI—Production Milling, General Considerations ..... 123
*By R. W. Bolz*

Rotating Disks—stress calculations and analysis for external loading ..... 132
*By A. H. Ehlinger*

Machine Hydraulics—Part VI—Trouble Shooting ..... 139
*By Albert H. Dall*

Engraves Cylinders from Flat Patterns ..... 141

Sandwich Materials—combine strength and lightness ..... 142

Edison's Tenet—Is It Needed? (Editorial) ..... 147

Helical Spring Design Tables (Data Sheet) ..... 153
*By H. F. Ross*

Aluminum Alloys, Wrought R300 Series (Materials Work Sheet) ..... 159

Itemized Index ..... 7

Topics ..... 98

Designs of the Month ..... 148

Applications of engineering parts, materials and processes ..... 152

Assets to a Bookcase ..... 163

New Parts and Materials ..... 164

Engineering Dept. Equipment ..... 176

Noteworthy Patents ..... 178

Men of Machines ..... 180

Design Abstracts ..... 184

Business and Sales Briefs ..... 192

Calendar of Meetings ..... 194

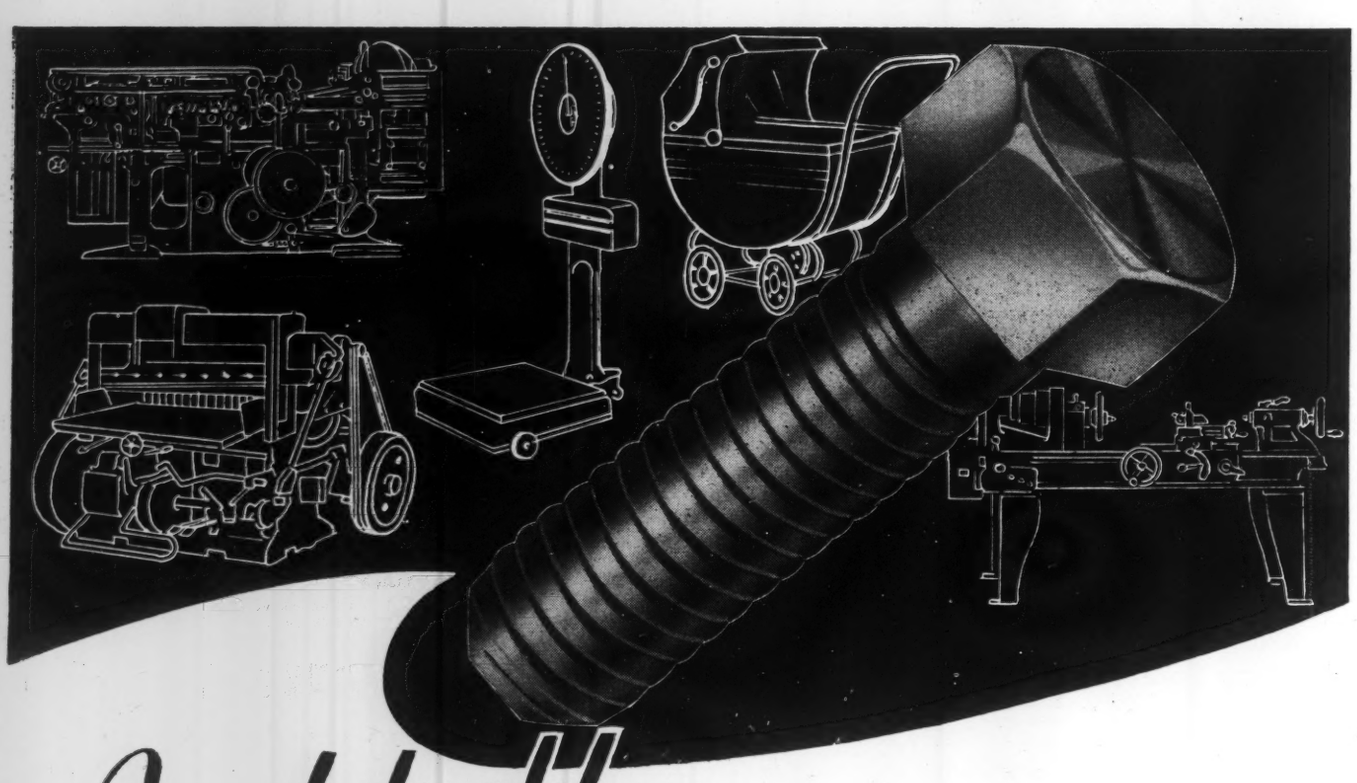
New Machines ..... 196

Helpful Literature ..... 259



Subscription in United States and possessions, Canada, Cuba, Mexico, Central and South America: One year, $10. Single copies, $1.00. Other Countries One year, $15.


Copyright 1947 by The Penton Publishing Company.



# *Justifiably Famous* FERRY Shinyheads

To enhance the value of your product—specify *justifiably famous* Shinyheads. They give that finishing touch, that extra sales appeal, along with extra quality.

Shinyheads are hexagon head cap screws—*Full Finished*—of high carbon C-1038 steel, with bright, shiny heads—completely machined top and bottom . . . bearing surface washer faced. Top of head chamfered . . . sides parallel and smooth, mirror finish. Threads uniform and accurate to close tolerance dimensions for perfect fit to standard gauges.

**Special Note—Very Important**—In addition, Ferry Cap SHINYHEADS include *all points machine turned and chamfered.*

## The FERRY CAP & SET SCREW Co.

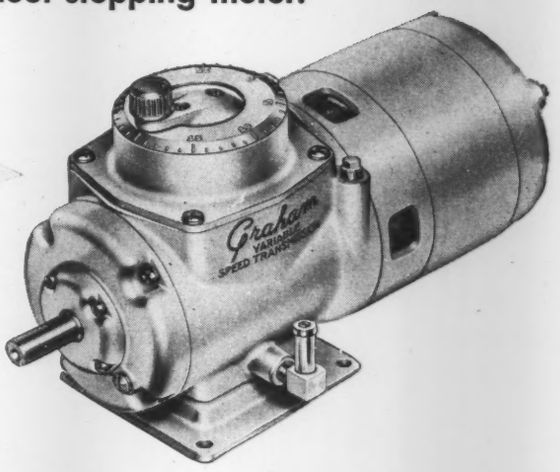
2177 SCRANTON ROAD • • • • • • CLEVELAND 13, OHIO

*Pioneers and Recognized Specialists Cold Upset Screw Products since 1907*

CAP AND SET SCREWS • CONNECTING ROD BOLTS • MAIN BEARING BOLTS • SPRING BOLTS AND SHACKLE BOLTS • HARDENED AND GROUND BOLTS
SPECIAL ALLOY STEEL SCREWS • VALVE TAPPET ADJUSTING SCREWS • AIRCRAFT ENGINE STUDS • ALLOY STEEL AND COMMERCIAL STUDS • FERRY PATENTED ACORN NUTS

**Early deliveries**
with or without built-in motor

1 All speeds — top to zero.
2 Close speed-holding over a wide range.
3 Extreme compactness.
4 Rapid reversal where wanted without stopping motor.
5 Multiplied torque at low speeds.
6 Accurate return to pre-set speed.




★ ONLY **Graham** gives you all 6 features—in a variable speed drive

## ★ at a price that keeps your machine competitive!

Now the machine you build can have all the advantages of a full speed range — from top to zero (plus reverse where wanted)—and still be sold competitively. Graham prices have been reduced more than half by simplified design and volume-production economies. Some models are priced as low as $50 (without motor.) That means you can apply the full advantages of Graham variable speed drive to low-power machines such as small tools, office machines, pumps, cutting torches, etc. — *and still remain competitive as to price!*

Graham is the only variable speed drive built as a straight line extension of a standard induction motor. It is a model of compactness, requiring no more fastenings than a single-speed motor. Model 40 (for ¼ to ¾ HP motors) and Model 15 (up to ⅛ HP) are available with or without motors — see tables below — or with built-in parallel shaft or right-angle gear units, reductions, or step-ups; with speeds down to zero and a moderate reverse, or equal speeds both sides of zero. Wide choice of controls; direct or remote, includes: manual, micrometer, lever, switch, or selsyn types, or combinations according to requirements.

Graham performance is proved by 8 years of success as standard equipment on leading machines. For complete information, write us for Bulletin 509, with prices and delivery.

**GRAHAM TRANSMISSIONS, INC.**
**3754 N. Holton Street • Milwaukee 12, Wisconsin**

*For Coupled Motor or Offset Drive.*

•

*With built-in motor. Note that the built-in motor is especially designed to form an integral streamlined part of the drive.*

•

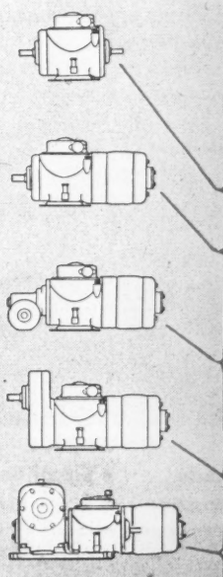
*With built-in motor and built-in spur reduction or step-up.*

•

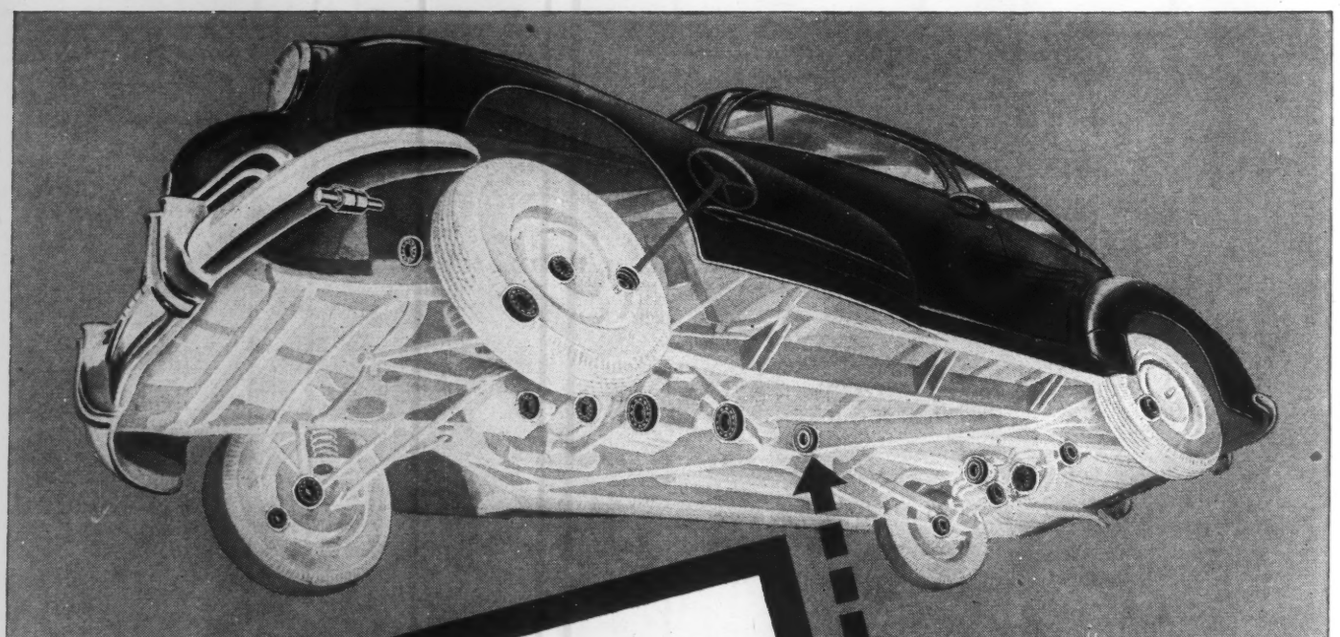
*With built-in motor and built-in worm reduction, Model 15. Output shaft may extend horizontally to either side, or vertically up or down. Additional ratios available—6:1, 10:1, 15:1, 30:1, and 60:1.*

•

*With built-in motor and built-in worm reduction, Model 40. Output shaft extends both sides horizontally or vertically up or down. Additional ratios available — 9:1, 12:1, 18:1, 36:1 and 47:1.*



| Model | Input Speed | Output Speed Range | In Lbs. Torque Rating | | Approx. Ins. Overall Dimensions | | | Motor H.P. |
|---|---|---|---|---|---|---|---|---|
| | | | At Max. Speed | At Min. Speed | Lgth. incl. shaft ext. | Width | Height | |
| 15 | 3600 | 1100/0 | 3.5 | 7.5 | 8¼ | 4⅝ | 5⅝ | 1/15 to ⅛ |
| 40 | 3600 | 1100/0 | 30 | 60 | 14½ | 7 | 8 | ¼ to ¾ |
| 15M | 3600 | 1100/0 | 3.5 | 7.5 | 11½ | 4⅝ | 5⅝ | 1/15 to ⅛ |
| 40M | 3600 | 1100/0 | 30 | 60 | 19½ | 7 | 8 | ¼ to ¾ |
| 15MR5 | 3600 | 220/0 | 15 | 35 | 13 | 4⅝ | 6¾ | 1/15 to ⅛ |
| 40MR5 | 3600 | 220/0 | 140 | 280 | 22 | 7 | 10 | ¼ to ¾ |
| 40MR2.8 | 3600 | 400/0 | 80 | 160 | 22 | 7 | 10 | ¼ to ¾ |
| 15MS2.5 | 3600 | 2750/0 | 1.3 | 2.8 | 13 | 4⅝ | 6¾ | 1/15 to ⅛ |
| 40MS2.8 | 3600 | 3100/0 | 10 | 20 | 22 | 7 | 10 | ¼ to ¾ |
| 15MW20 | 3600 | 55/0 | 35 | 75 | 12¾ | 4⅝ | 5⅝ | 1/15 to ⅛ |
| 15MW40 | 3600 | 28/0 | 60 | 120 | 12¾ | 4⅝ | 5⅝ | 1/15 to ⅛ |
| 40MW6 | 3600 | 190/0 | 120 | 250 | 24 | 8½ | 10½ | ¼ to ¾ |
| 40MW24 | 3600 | 46/0 | 420 | 840 | 24 | 8½ | 10½ | ¼ to ¾ |
| 40MW60 | 3600 | 19/0 | 800 | 1700 | 24 | 8½ | 10½ | ¼ to ¾ |



# No lubrication needed after 9 years' service

## (MR. K*. COULDN'T BELIEVE IT)

**Lubricated for life**

Cutaway N-D-Seal ball bearing. Made to be forgotten. Gives years of trouble-free service in machinery of every kind.

Mr. K. takes good care of his Oldsmobile.

After his propeller shaft ball bearing had given nine years' continuous service, he decided that it simply must be lubricated.

When we explained that this N-D-Seal ball bearing is lubricated for life, Mr. K. couldn't believe it. We told him the same was true of his rear wheel bearings, and his fan and water pump and clutch throw-out bearings.

All of this because of advances in bearing design.

For that and other reasons, the number of points which require lubrication in an Olds have been reduced from 31 to 21. That is why a modern car can now be greased in one half the time it used to take.

In machinery of every kind, the N-D-Seal ball bearing has reduced maintenance costs. Because dirt is sealed out, and the lubricant sealed in, no further attention, no adjustment for wear is required. Write for your copy of the free booklet, "Why Anti-Friction Bearings."

*Name on request.

*nothing rolls like a ball*

# NEW DEPARTURE

## *forged steel* BALL BEARINGS

**6 VITAL ADVANTAGES**

- Higher speeds
- Greater accuracy
- Simplified design
- Every kind of load
- Lower maintenance costs
- Less friction — less wear

NEW DEPARTURE • DIVISION OF GENERAL MOTORS—BRISTOL, CONN. • Branches in DETROIT • CHICAGO • LOS ANGELES

# Itemized Index

## Classified for convenience when studying specific design problems

### Design and Calculations


Cargo loader for aircraft, design of, Edit. 150-151
Compass, electronic, Edit. 106
Cyclic variations in speed, Edit. 108-111, 182
Double vertical spindle grinder design, Edit. 149
Flat springs in strips, Edit. 105
Helical spring design (data sheet), Edit. 153-158
Hydraulic circuit analyzer, Edit. 121-122
Machine hydraulics, Edit. 138-140
Mechanism, rotary to linear, Edit. 141
Modified stereoscope design, Edit. 148
Production milling, general considerations, Edit. 123-131
Pyrometer, silver shields for, Edit. 106
Rectifiers, selenium, Edit. 112-114
Rotating disks, stress calculations, Edit. 132-137, 186, 188, 190
Rubber parts design, Edit. 115-120
Sandwich materials, Edit. 142-146


### Engineering Department


Equipment, Adv. 17, 31
Instruments, Edit. 176; Adv. 24, 273
Management, Edit. 101-104
Supplies, Adv. 189, 268, 280, 282, 287


### Materials


Adhesives, Edit. 166
Aluminum alloys, Edit. 159-162; Adv. 15, 203, 214, 230
Beryllium, Edit. 105
Carbides, cemented, Edit. 105; Adv. 206
Copper alloys, Adv. 207, 208, 246
Felt, Adv. 252
Glass, Adv. 46
Laminates, Edit. 142-146
Magnesium alloys, Adv. 169
Molybdenum alloys, Adv. 183
Nickel alloys, Adv. 23, 87, 204, 217
Plastics, Edit. 152, 163, 174; Adv. 14, 60, 86, 197, 198
Rubber and synthetics, Adv. 39, 48, 193
Silicones, Adv. 190
Steel, Edit. 165; Adv. 21, 32, 175


### Parts


Balls, Adv. 275, 283
Bearings:
- Ball, Adv. 6, 202, 227, 241, 266, 270, 289
- Needle, Adv. 211
- Pillow blocks, Adv. 90
- Roller, Adv. 11, 16, 50, 205, 223, 236, 244, 255, 256, 265
- Sleeve, Adv. 167, 254, 258
- Spherical, Adv. 210

Belts and belting, Adv. 88, 89, 284
Bushings, Adv. 262, 287
Carbon parts, Adv. 26, 52, 250, 264
Castings:
- Centrifugal, Adv. 41
- Sand, Adv. 61, 222

Chains, roller, 18, 19, 40, 97, 251
Clutches, Edit. 152, 178; Adv. 38, 248, 264, 269, 272, 291
Compressors, Edit. 164, 178
Controls (see Electric, Cable, etc.)
Counters, Edit. 164, 168; Adv. 199
Couplings, Adv. 81, 245
Cylinders, Edit. 172, 174
Dials, Adv. 247
Disks, Edit. 132-137, 186, 188, 190
Electric accessories, Edit. 170, 172; Adv. 281
Electric controls:
- Capacitors, Edit. 166
- Control assemblies, Adv. 215, 229, back cover
- Rectifiers, Edit. 112-114
- Relays, Adv. 8, 231
- Resistors Adv. 74
- Solenoids, Edit. 164
- Starters, Adv. 55, 181
- Switches, Edit. 166, 170; Adv. 42, 43, 94
- Thermostats, Edit. 164, 172
- Timers, Adv. 270
- Transformers, Edit. 168

Electric motors, Edit. 165, 166, 170; Adv. 1, 25, 32, 49, 51, 67, 68, 196, 200, 234, 237, 252, 272 279 280, 284, inside back cover
Engines, Edit. 166, 184; Adv. 53, 248, 264, 269, 270, 283
Fastenings:
- Locking, Adv. 66, 84, 201, 218, 266, 274
- Nuts, bolts, screws, Adv. 4, 64, 70, 77, 177, 194, 220, 232, 246, 281, 292
- Rivets Adv. 271

Filters, Edit. 165, 168; Adv. 30, 253, 272
Fittings, Adv. 209
Forgings, Adv. 85, 239, 261, 262
Gages, pressure, etc. (see Instruments), Edit. 121-122; Adv. 33, 219
Gears, Edit. 108-111, 182; Adv. 13, 28, 56, 75, 271, 272, 274, 282, 286
Hydraulic and pneumatic equipment:
- Accumulators, Adv. 195
- Controls, Adv. 45
- Cylinders, Edit. 168
- Motors, Edit. 168; Adv. 240
- Pumps, Edit. 164, 172; Adv. 9, 95, 212, 221, 275
- Systems, Edit. 138-140, 168; Adv. 99
- Valves, Edit. 170, 178; Adv. 76, 224, 271, 275

Instruments, Edit. 106, 107
Joints, Adv. 256, 266
Lamps and lighting, Adv. 78
Lubrication and equipment, Edit. 172; Adv. 59, 279
Machined parts, Adv. 287
Motors (see Electric Motors)
Mountings, vibration, Edit. 165; Adv. 83
Nozzles, Edit. 174
Plastic parts, Adv. 179
Plugs, Adv. 257
Pneumatic equipment (see Hydraulic and pneumatic)
Powder-metal parts, Adv. 65
Pulleys and sheaves, Edit. 165; Adv. inside front cover, 35, 91
Pumps (see also Hydraulic and pneumatic), Adv. 191, 235, 268, 284
Rings, retaining, Adv. 72, 73
Rubber and synthetic parts, Edit. 115-120; Adv. 213
Seals, packings, gaskets, Adv. 2, 27, 37, 58, 62, 63, 71, 171, 173
Shafts, flexible, Adv. 273
Sheet-metal parts, Adv. 82, 279
Speed reducers, Edit. 165; Adv. 57, 92, 100, 185, 228, 243, 262, 281
Spindles, precision, Adv. 93
Springs, Edit. 105, 153-158; Adv. 44, 192, 268
Stampings, Adv. 10, 274
Transmissions, variable speed, Edit. 174; Adv. 5, 79
Tubing:
- Finned, Adv. 80
- Metallic, Edit. 165; Adv. 29, 96, 225, 226, 242
- Nonmetallic, Edit. 174

Valves (see also Hydraulic and pneumatic), Adv. 20, 280
Weldments and equipment, Edit. 163, 164, 172; Adv. 22, 187, 216, 238, 249


### Production


Brazing equipment, Adv. 47
Engraving, Edit. 141
Grinding, Edit. 105
Hardening, Edit. 152; Adv. 69, 263
Lathe machining, Edit. 163
Machines, special, Adv. 54, 269
Milling, Edit. 123-131
Presses, Adv. 36
Testing and equipment, Adv. 12
Tools and accessories, Adv. 233, 273



**MACHINE DESIGN is indexed in Industrial Arts Index and Engineering Index Service, both available in libraries generally.**

# STRUTHERS-DUNN

## HEAVY-DUTY RELAYS

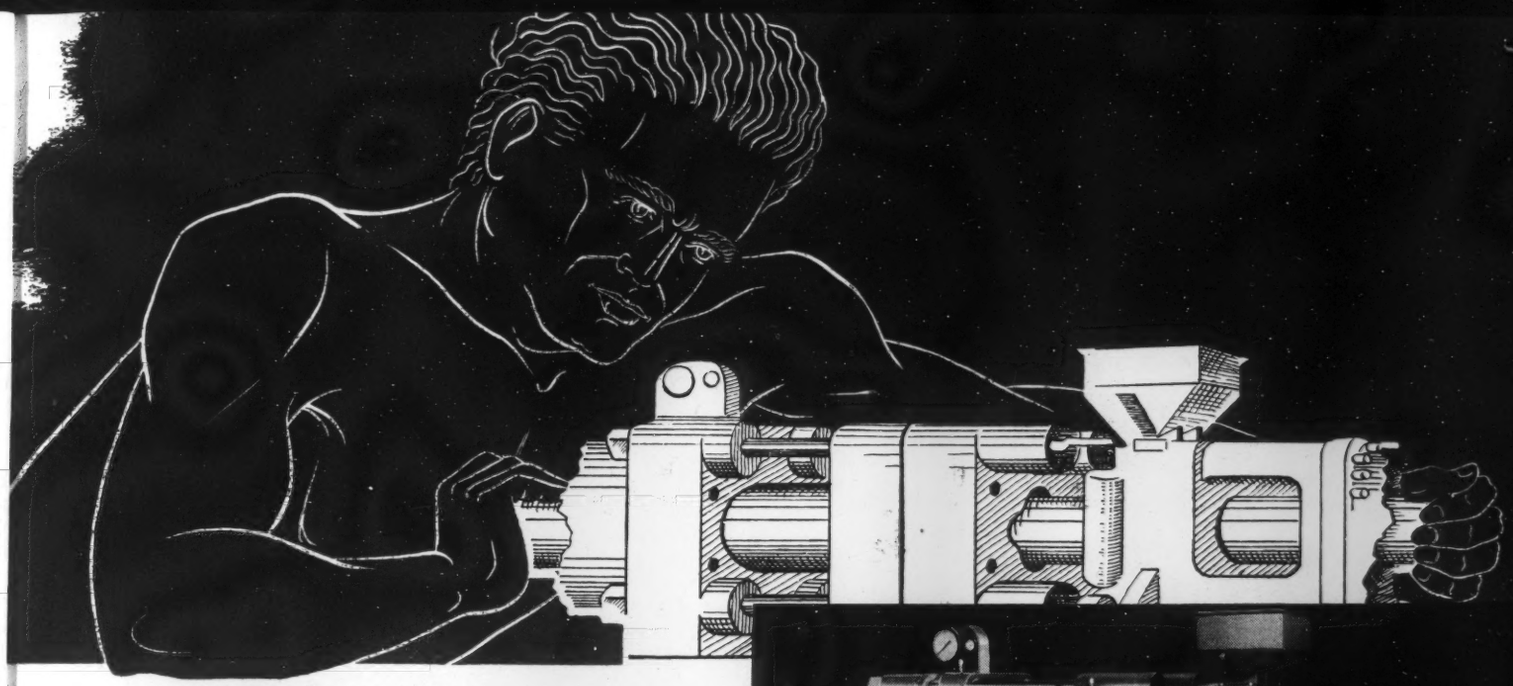
In addition to many standard types of large power relays, Struthers-Dunn can supply adaptations for applications involving high inrush loads, radio-frequency or high-voltage insulation, extra long life, and other special service conditions. All units include three point armature support for exceptionally quiet operation, wiping action on the fine silver contacts and numerous other features.

Write for Data Section 4671 for detailed information on both standard and special types.

S-D
STRUTHERS-DUNN, INC.

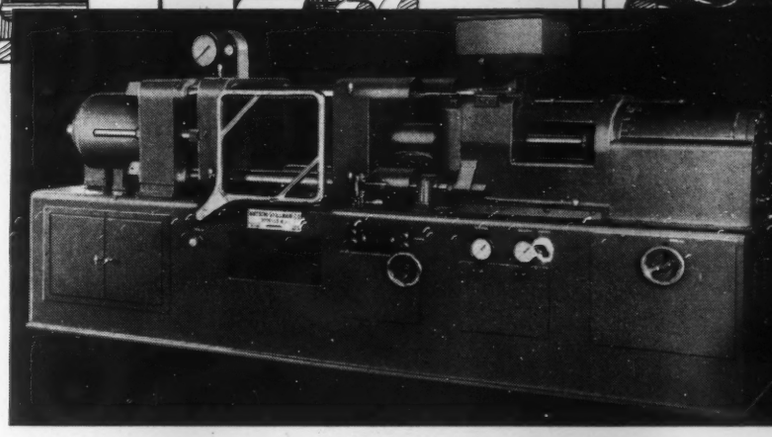
**STRUTHERS-DUNN, INC., 146-150 N. 13th St., Phila. 7, Pa.**

ATLANTA • BALTIMORE • BOSTON • BUFFALO • CHICAGO • CINCINNATI • CLEVELAND • DALLAS
DENVER • DETROIT • HARTFORD • INDIANAPOLIS • LOS ANGELES • MINNEAPOLIS • MONTREAL
NEW YORK • PITTSBURGH • ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO



# OILGEAR FLUID POWER on Injection Molding Machines

**Rapidly closes die . . . cushions die closing . . . maintains a preset clamping force on die . . . moves injection ram rapidly . . . automatically reduces injection speed to optimum . . . dwells under pressure as plastic sets . . . returns injection ram rapidly . . . slowly "breaks away" die . . . rapidly opens die . . . slows down to strip parts from die.**



Watson-Stillman 12-oz. Injection Molding Machine equipped with Oilgear One-Way Variable Delivery Pump and an Oilgear Constant Delivery Pump together with required control valves.

The most productive method of making plastics parts is the injection molding process. An outstanding manufacturer of injection molding machines is the Watson-Stillman Company. Pictured above is the Watson-Stillman 12-ounce injection molding machine, equipped with two Oilgear pumps and the requisite Oilgear control valves.

Control of operations can be either manual or automatic. Closing the guard gate starts the cycle. All that follows is performed automatically by Oilgear. The molding die clamping ram closes rapidly yet final closure of the costly die is completely cushioned. Preset pressure on the die is held while the injection ram darts in, slows down to optimum speed to inject the hot plastic charge home and dwells while the plastic sets. Then the injection ram retreats at high speed. The clamping ram breaks the die apart carefully, opens swiftly then slows down for stripping the finished piece from the mold.

These unique time-saving, die-saving, money-saving, better product producing functions possible at variable and preset speeds are gained by means of an Oilgear one-way variable delivery pump with automatic pressure unloading control and electric remote control, an Oilgear constant delivery pump, associated control valves and cylinders. The application represents only one of many machine problems solved by Oilgear engineers long-experienced in the application of a comprehensive line of Fluid Power equipment to an equally broad range of machines. Foremost in Fluid Power, Oilgear can solve your machine problems too. THE OILGEAR COMPANY, 1305 W. Bruce Street, Milwaukee 4, Wisconsin.

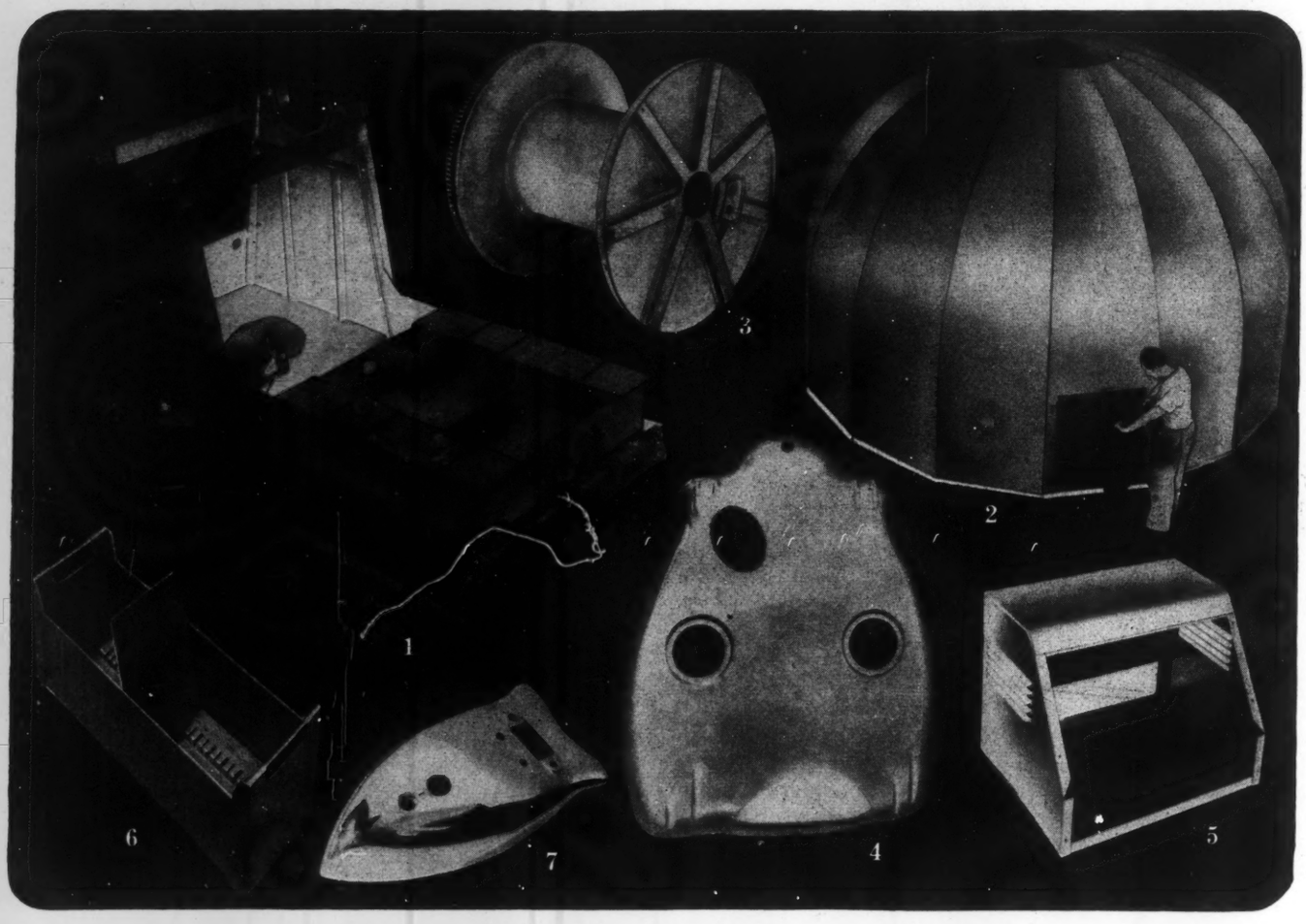
### ARE YOU TRYING TO:

1. Apply large forces through long . . . or short . . . strokes at variable speeds?
2. Obtain automatic work cycles, variable speeds in either direction . . . with or without preset time dwell?
3. Apply large forces through continuous or intermittent reciprocating cycles at constant or variable velocities?
4. Obtain extremely accurate control of either position or speed of a reciprocating member?
5. Apply accurately variable pressure either static or in motion?
6. Closely synchronize various motions, operations or functions?
7. Apply light . . . or heavy . . . forces at extremely high velocities through either long or short distances of travel?
8. Obtain continuous automatic reversing drives at constant R.P.M. or over a wide range of speed variation?
9. Obtain accurate remote control of speed and direction of rotation, rates of acceleration and/or deceleration?
10. Obtain constant horsepower output through all or part of a speed range?
11. Obtain automatic torque control?
12. Obtain accurately matched speed of various rotating elements?
13. Obtain constant speed output from a variable speed input?
14. Obtain full preset automatic control, elimination of problems of shock, vibration, etc.?

*You Need Oilgear!*

*Oilgear Fluid Power*

# 7 UNUSUAL METAL WORKING JOBS

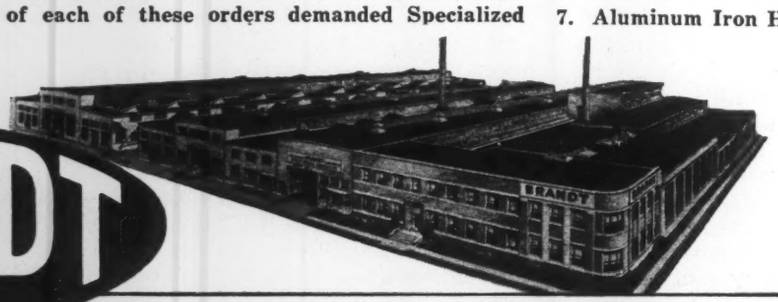



## Specialized Work—ranging from 14,000 lbs. to a few ounces—for 6 exacting customers

Brandt's ability to solve out-of-the-ordinary metal working problems in an extreme range of sizes and metals is illustrated by the 7 products shown above. The aluminum electric iron stampings were mass-produced to close specifications on a rush order. In contrast, the 14,000 pound precision Weldments (1), were tailor made to exacting Naval specifications. The Protective Housings for Naval Guns (2) are huge 15 ft. diameter units of 16 gauge steel, produced on assembly line basis, and made in their entirety by Brandt.

The other products shown were made for Specialized Aircraft, Electronic, Marine and Office equipment. Widely different in size, metals, specifications and quantity, the production of each of these orders demanded Specialized Facilities.

1. 14000 lb. Steel Weldments
2. Protective Naval Gun Housings
3. Intricate Steel Weldments
4. Aluminum Aircraft Fuel Tanks
5. Steel Radio Jackets
6. Steel Office Files
7. Aluminum Iron Housings



ALL UNDER ONE ROOF

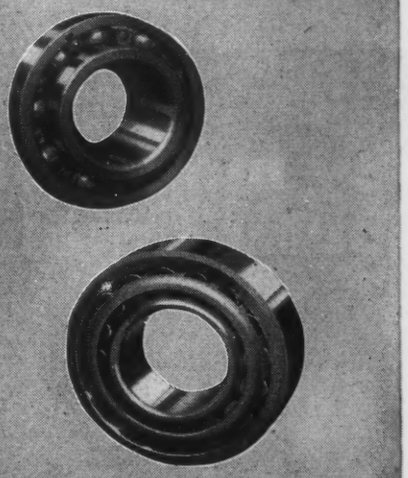
BRANDT
BALTIMORE

CHARLES T. BRANDT, INC., 1700 RIDGELY ST., BALTIMORE-30, MD.

*Precision* METAL CRAFTSMEN SINCE 1890 ★ ★ ★ ★

# BALL AND ROLLER BEARINGS

## BY LINK-BELT



● In countless applications, Link-Belt Ball and Roller Bearings are protecting costly equipment, by their well-known ability to take either radial or thrust loads, or a combination of both, and their self-aligning features.

Available in unmounted sizes or mounted units, pillow blocks, cartridge, flanged, hanger and take-up units. Send for catalogs Nos. 2094 and 2095.

**ENGINEERED AND BUILT TO HIGHEST STANDARDS BY**

**LINK-BELT COMPANY**

*THE LEADING MANUFACTURER OF CONVEYING AND MECHANICAL POWER TRANSMISSION MACHINERY*

Chicago 9, Indianapolis 6, Philadelphia 40, New York 7, Atlanta, Dallas 1, Houston 2, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8.

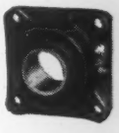
Offices, Factory Branch Stores and Distributors in Principal Cities.

10,544

**BALL BEARINGS**
**LIGHT SERIES 200**

PILLOW BLOCK-SOLID HOUSING

PILLOW BLOCK-SPLIT HOUSING

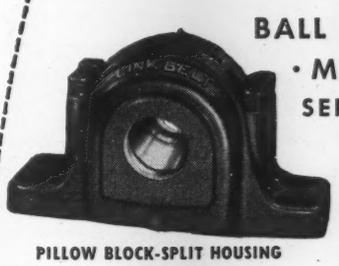


FLANGE UNIT

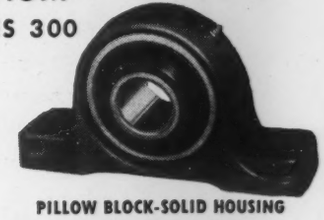
TAKE-UP UNIT

HANGER UNIT

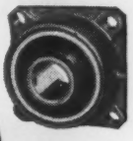
**BALL BEARINGS**
**• MEDIUM •**
**SERIES 300**



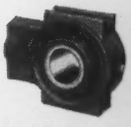
PILLOW BLOCK-SPLIT HOUSING



PILLOW BLOCK-SOLID HOUSING

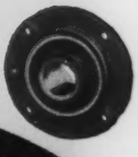


FLANGE UNIT



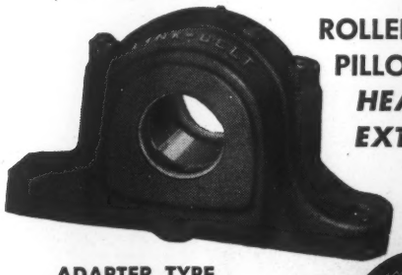
TAKE-UP UNIT

CARTRIDGE UNIT



FLANGE CARTRIDGE UNIT

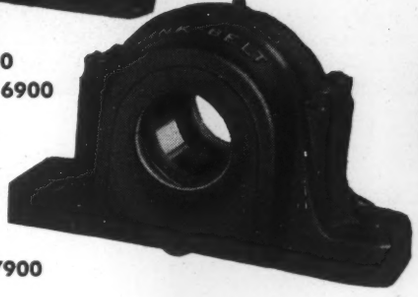
**ROLLER BEARING PILLOW BLOCKS • *HEAVY AND EXTRA HEAVY***



**ADAPTER TYPE**
**HEAVY SERIES 6800**
**EXTRA HEAVY SERIES 6900**

•

**PRESS FIT ON SHAFT**
**HEAVY SERIES 7800**
**EXTRA HEAVY SERIES 7900**



**LINK-BELT BALL AND ROLLER BEARINGS**

# why make mountains out of molecules?

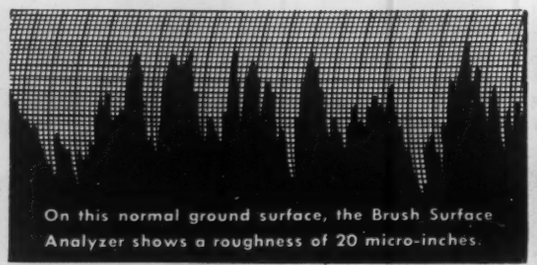
**Because that's the way to learn about wear! Take a profile of a "smooth" ground surface, blow it up till millionths look like mountains—and then you see what happens to bearing surfaces.**

**Above is the profile recording of a normal ground surface as shown by the Brush Surface Analyzer. Those sharp ups and downs are actually the invisible grinder scratches and chatter marks that rupture oil film, opening the way to scoring and burning.**

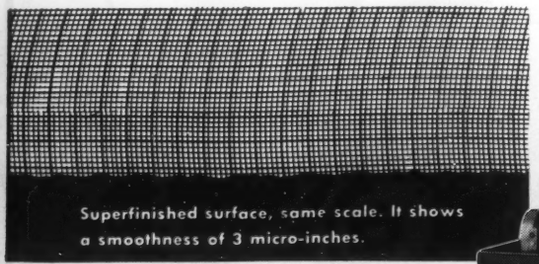
**At right, below, is the Brush analysis of a *Superfinished* surface, which is seven times as smooth as the one at left. With a surface such as this, a bearing will last indefinitely.**

**Superfinishing is a quick, simple, inexpensive process. Not only does it pay for itself through the better service it assures, but Superfinishing can often replace other, more costly processes. Full information available on request.**

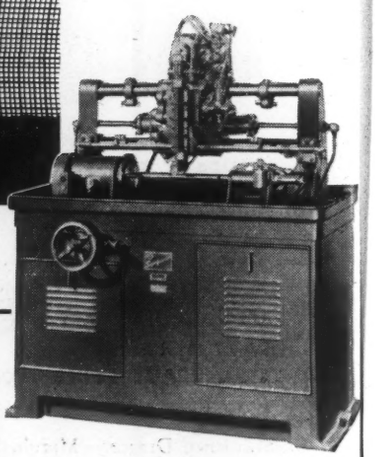
**GISHOLT MACHINE COMPANY** *1245 East Washington St. • Madison 3, Wisconsin*



On this normal ground surface, the Brush Surface Analyzer shows a roughness of 20 micro-inches.



Superfinished surface, same scale. It shows a smoothness of 3 micro-inches.



**THE GISHOLT ROUND TABLE** *represents the collective experience of leading specialists in the machining, surface finishing, and balancing of round and semi-round parts. We welcome your problems.*

FRACTIONAL HORSEPOWER GEARING

# WHY YOU SHOULD LET G-S MAKE *YOUR* SMALL GEARS

SMOOTHER, better performance and longer life characterize the Small Gears we make. They give *added dependability* to the devices in which they are used. The superior advantages of G-S Small Gears are the result of more than a quarter century of specialization . . years of developing men, materials and machinery to their present high degree of efficiency. Here, the best possible solutions to your small gear problems can be determined by our skilled engineers. Specifications and production procedures, however exacting, will be established and carried out quickly and at moderate cost. Discuss your needs with a G-S Small Gear Specialist. Get suggestions, ideas, and cost estimates. This friendly service doesn't obligate you at all.

*The G-S Catalog Bulletin describes many different types and applications of G-S Small Gears. Please ask for a copy on company stationery.*

GEAR Specialties

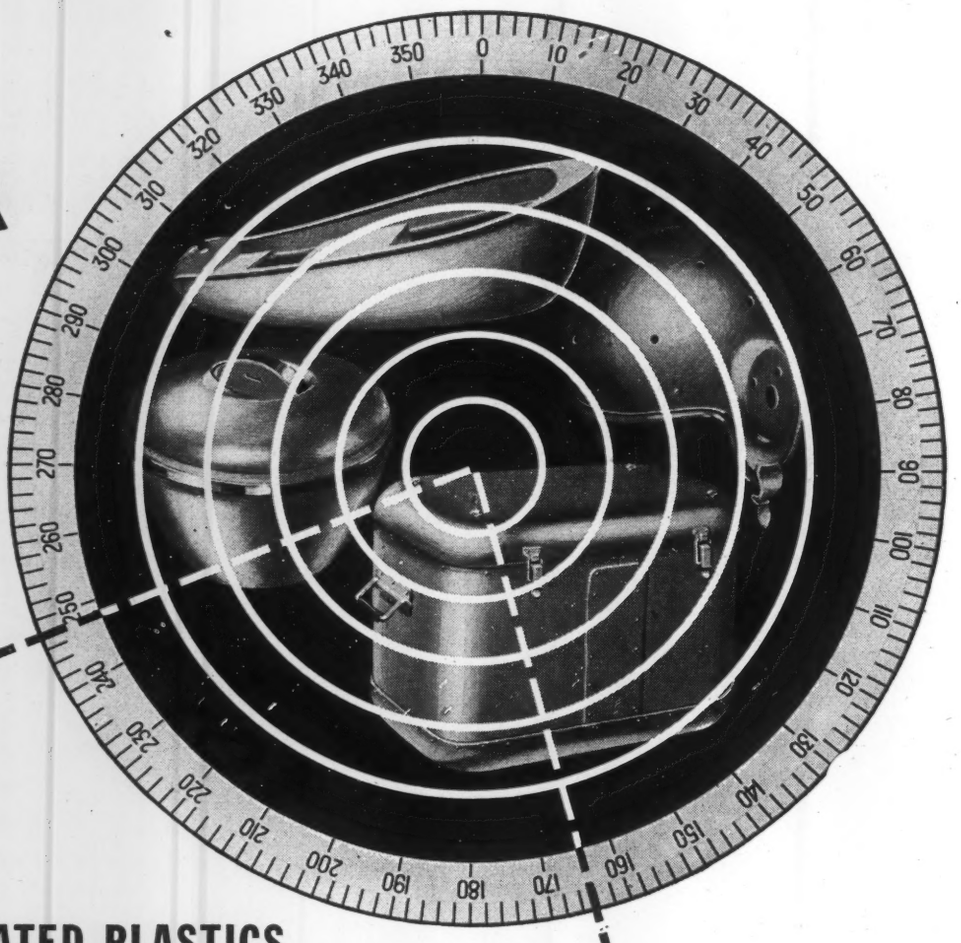
Spurs • Spirals • Helicals • Bevels • Internals • Worm Gearing • Racks • Thread Grinding

2635 WEST MEDILL AVENUE • CHICAGO 47, ILLINOIS

MEMBER OF AGMA

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARS

# How RADAR spotted postwar targets




## ...FOR LAMINATED PLASTICS

One of radar's earliest problems has brought about one of the most far-reaching postwar developments in plastics! The problem: a streamlined, light-weight, all-weather housing for bulky antennas. The answer: low-pressure laminating of plastic materials!

Everyone is familiar with the bulging "radomes" on many of our wartime aircraft. Those big shapes, with compound curves covering large areas, could never have been turned out in quantity by conventional molding methods. Low-pressure laminating of duck and glass cloth layers impregnated with BAKELITE resins solved the problem—and spawned a host of postwar applications!

Big shapes...complex forms containing deep undercuts... these and other projects that are well-nigh impossible by ordinary plastic molding techniques are made comparatively easy by this new war-born process.

Industry will find many uses for low-pressure laminates—thanks to their high dielectric strength, dimensional stability, mechanical strength and other desirable properties that are dependent upon choice of base materials and the correct BAKELITE laminating varnish. They permit simple molds—color may be incorporated—they may be formed in the flat and *postformed* in a wide variety of shapes—they are the *economic* answer to many product design problems.

Write Department 13 for further information on low-pressure laminating-molding.

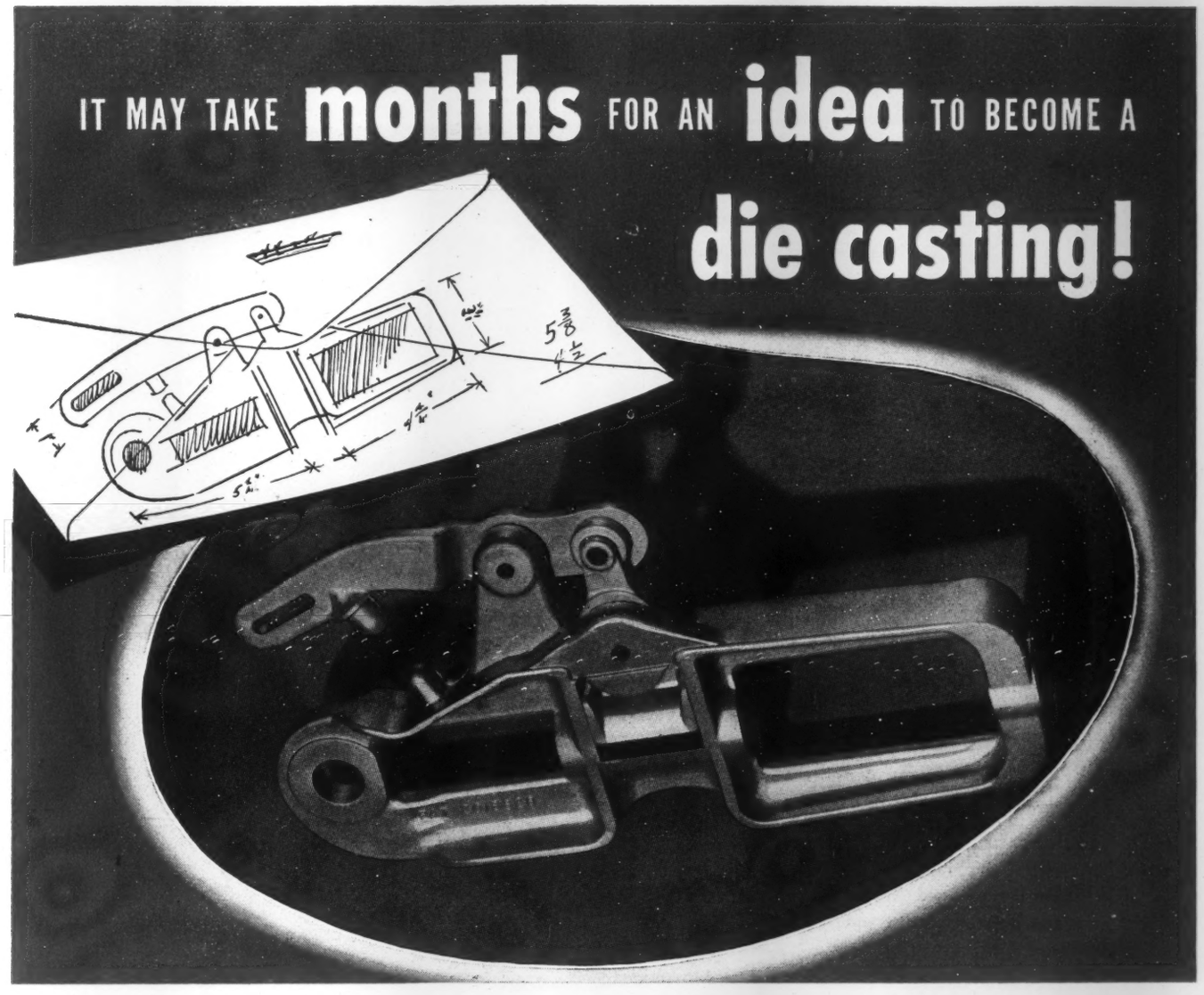
**BAKELITE**

TRADE-MARKS

**PLASTICS**

BAKELITE CORPORATION, *Unit of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

# IT MAY TAKE **months** FOR AN **idea** TO BECOME A **die casting!**



So *now* is the time to make the rough sketches and designs for the die-cast aluminum parts you'll need next fall.

Alcoa Aluminum Die Castings help you cut production costs. The parts require less machining and finishing; dimensions are accurate to close tolerances; and the pieces can be as intricate in design as the function of the parts require.

Aluminum die castings are light in weight, strong to carry load and withstand impact.

While your ideas are still sketches on an old envelope, or if they've reached the drawing board, let our die castings engineers check your designs and calculations. Then you'll be sure of getting *all* the weight savings and fabricating advantages from Alcoa Aluminum Die Castings. ALUMINUM COMPANY OF AMERICA, 1940 Gulf Building, Pittsburgh 19, Pennsylvania. Sales offices in leading cities.

**MORE people want MORE aluminum for MORE uses than ever**

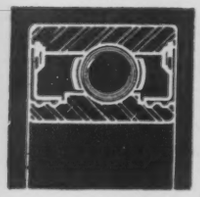
**ALCOA** FIRST IN **ALUMINUM**

IN EVERY COMMERCIAL FORM

**BEARING FACTS NO. 3**

# The "Cartridge" Bearing

## TOMORROW'S BEARING— HERE TODAY



Standard Type

This revolutionary forward step in bearing design has proved itself on the toughest assignments for the past eleven years. It is not only a highly efficient precision bearing, but its self-sealing features also help you improve the performance and lower the cost of producing your own equipment through streamlined design. Here are the facts:

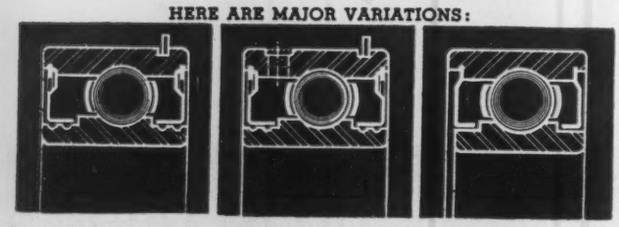
*Why it is a Better Bearing*

- 100% more grease capacity than any other standard self-sealed bearing.
- Factory packed with Norma "Stability-Tested" grease. Relubricate only after years of service.
- Grease retained close to balls and raceways by built-in, wearless seals.
- Flanged seals with grease grooves provide a dam against leakage; prevent entrance of dirt.

*How it aids Your Design Problems*

- Eliminates up to 10 machining operations and up to 22 parts required with some conventional mounting.
- Prevents slippage, peening, cocking — obviates use of steel inserts in soft metal housings.
- Increases shaft strength; reduces overhang; provides compactness — locknuts and wide sealing parts are eliminated.

**HERE ARE MAJOR VARIATIONS:**



**Shoulder (snap) wire.** No housing shoulders needed. Seals removable.

**Grease filling opening.** Shoulder ring optional. Seals removable.

**Permanently sealed.** For shafts under 20 m/m. Seals not removable.

NOTE. Write for "Cartridge" Bearing Catalogue. Address Dept N

PATENTED BY NORMA-HOFFMANN

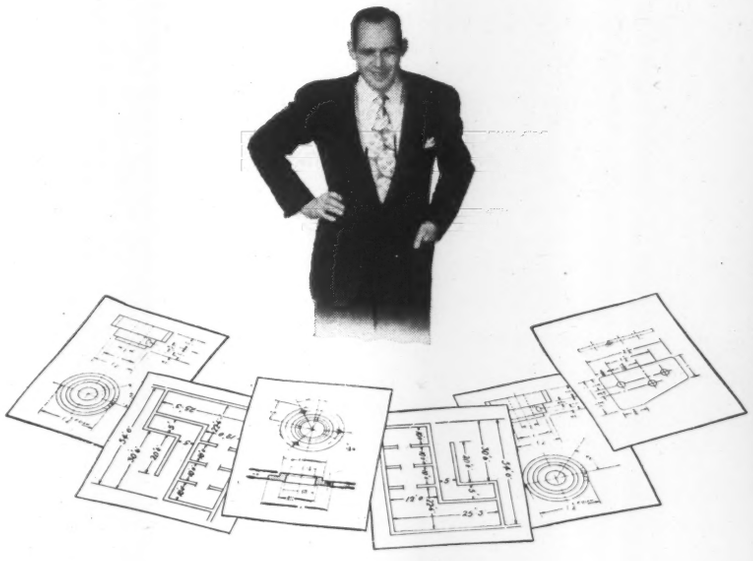
"NORMA-HOFFMANN"

PRECISION BALL, ROLLER AND THRUST BEARINGS

NORMA-HOFFMANN BEARINGS CORPORATION
STAMFORD, CONNECTICUT
FIELD OFFICES: New York, Chicago, Cleveland, Detroit, Pittsburgh, Cincinnati, Los Angeles, San Francisco, Portland, Ore., Seattle, Phoenix

# What to look for—

# *in changing to Black Line Prints*



**Look For Simplicity!**

You want equipment that will make black line prints directly from your tracings—in seconds—and in the simplest possible way. Bruning Printer-Developers are simple in construction and in operation. No complicated mechanisms to get out of order. No "gadgets" to confuse your operator. No plumbing to install—and no noxious fumes to dispose of.

**Look For Versatility!**

With the Bruning BW System, you get a *wide variety* of direct line print advantages. Besides regular BW Prints, you can have such features as colored lines on white or tinted backgrounds—card-weight or light weight prints—BW Transparents (intermediate reproducibles)—and BW Safety Film for salvaging worn or soiled tracings. Bruning research keeps you up to date in getting the most out of the BW Direct Line Process!

**Look For Flexibility!**

You want black line equipment that fits YOUR needs exactly—equipment that's neither too large nor too small. The Bruning BW System offers you Printer-Developers for every need, whether you make only a few prints a day or hundreds. You can have machines especially suited to cut-sheet or roll stock production, or for changing from photographic to black line prints at will!

**You Get These Six Major Advantages with the BRUNING BW SYSTEM**

1. **A versatile, simple method for making black or colored line prints directly from transparent or translucent originals.**
2. **45 years' experience in analyzing printmaking needs.**
3. **A complete direct-line printing process, including white and green tinted papers, thin, medium and card-weight papers, black, red or brown line prints. BW Transparents and BW Film (intermediate prints) to supplement original valuable tracings.**
4. **A complete line of printing and developing machines to fit every requirement.**
5. **A continuing service . . . because Bruning sells everything for the engineer and draftsman, not just BW equipment. Buying a BW machine is, therefore, not a "one-time sale."**
6. **Continuing research and development in the customer's interest.**

*Since 1897*

**CHARLES BRUNING COMPANY, INC.**

| NEW YORK | CHICAGO | | LOS ANGELES |
|---|---|---|---|
| Atlanta | Boston | Detroit | Houston |
| Kansas City | Milwaukee | Newark | Pittsburgh |
| St. Louis | San Francisco | Seattle | |

**It Pays to Investigate the BW System—Mail the Coupon!**

CHARLES BRUNING COMPANY, INC.
4726-32 Montrose Avenue, Chicago 41, Illinois
Gentlemen: I want to know more about Bruning BW Prints and equipment. Please send me information.

*Name*.....

*Company*.....

*Street*.....

*City*..... *State*.....

do you

# know Roller Chain...

## PUTS POSITIVE PERFORMANCE IN YOUR DESIGN!

• BALDWIN-REX ROLLER CHAIN DRIVES put plus value in your machines . . . add to product salability! For example, their positive action eliminates slippage and conserves power costs. They transmit more horsepower in less space, assuring compactness. Through the use of roller chains, you get the advantage of maximum flexibility in your drive design arrangements plus the inherent elasticity that protects machines against shocks and momentary overloads. And properly applied, they usually last the lifetime of the machine.

We're not talking through our hats on that long-life statement. In our product development laboratories, we actually prove the wear-resistant abilities of Baldwin-Rex. On machines such as this, the chain is run at excessively high speeds over small sprockets under conditions considerably more severe than actually encountered to determine life expectancy. In this manner, we obtain data on choice of materials, degree of heat-treatment, and design of parts that enable us to give you the best in roller chain . . . and assure you the most economical drive for your machines.

*When specifying roller chains for your machines, remember that you can simplify chain selection, generally cut costs, and improve deliveries by specifying standard roller chains. Your Baldwin-Rex man will be glad to give you all the facts and assist you with your application problems. Call him or write direct to Baldwin-Duckworth Division of Chain Belt Company.*

**BALDWIN·REX**

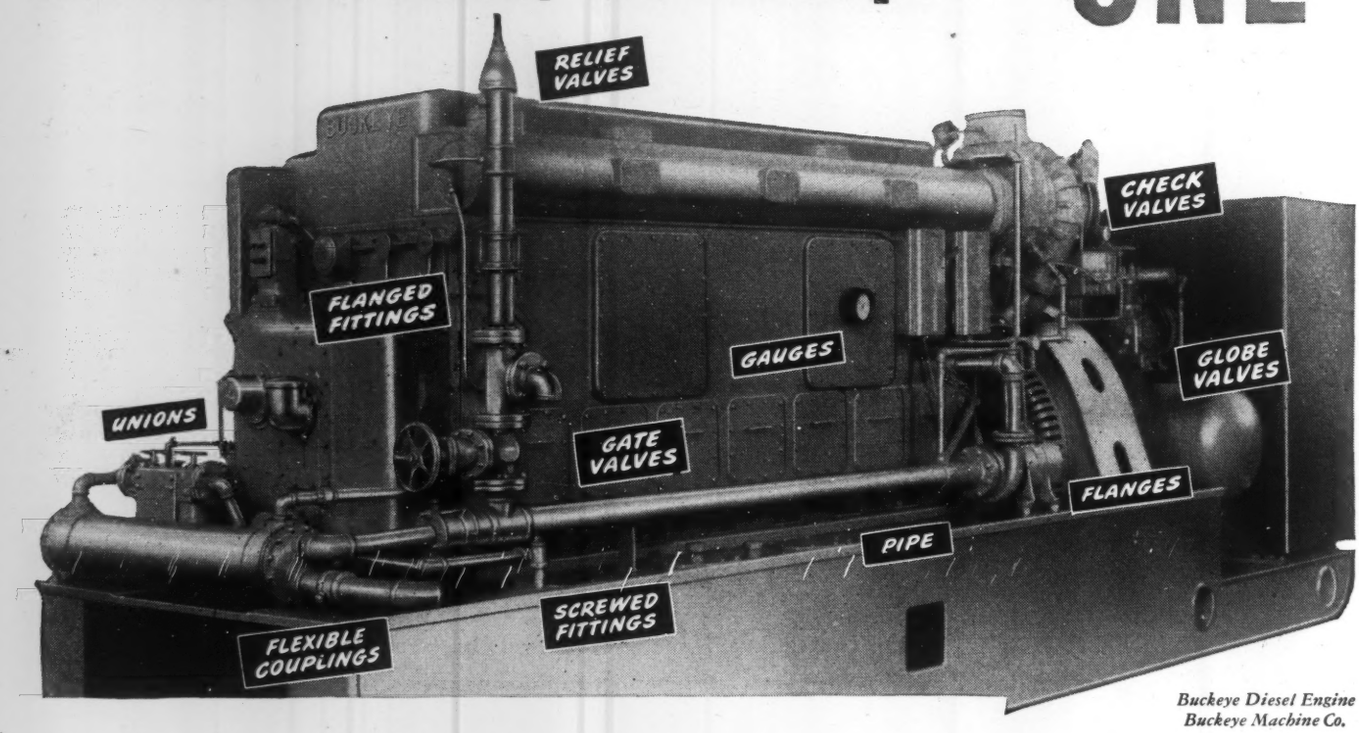
**ROLLER CHAINS**

**BALDWIN-DUCKWORTH DIVISION OF CHAIN BELT COMPANY**

**320 Plainfield Street, Springfield 2, Massachusetts**

# Everything in Piping . . . for Power Units, for example

**ONE** SOURCE OF SUPPLY
RESPONSIBILITY
STANDARD OF QUALITY




*Buckeye Diesel Engine*
*Buckeye Machine Co.*

For a diesel power unit, as for most any product design, one catalog is all you need to specify all piping equipment.

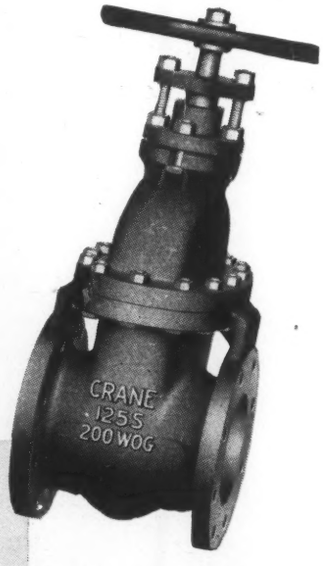
That's the Crane Catalog—key to the world's most complete selection of valves, fittings, pipe, accessories, and fabricated piping units for all applications. In brass, iron, and steel materials, the Crane line includes all types and sizes.

As the Crane Catalog saves precious time for designers—from plan to finished products there are added advantages in standardizing on Crane equipment. **One source of supply** means simplified buying and stocking procedures. **One responsibility** assures smooth piping assembly operations.

And most important—with Crane **one high standard of quality** in every part—both machinery builder and buyer know that piping equipment is thoroughly dependable. For more than 90 years, it has been giving complete satisfaction.

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Ill.
*Branches and Wholesalers Serving All Industrial Areas*

*(Below)* **CRANE STANDARD IRON BODY WEDGE GATE VALVES**—*typical of the uncommon quality Crane puts into commonly used valves. Improved design features reduced weight with greater strength, ideal flow characteristics, and easy servicing. Dependable and durable throughout. In all patterns and sizes; for steam pressures up to 125 lbs., 200 lbs. cold pressures. See Crane Catalog, pp. 101-106.*

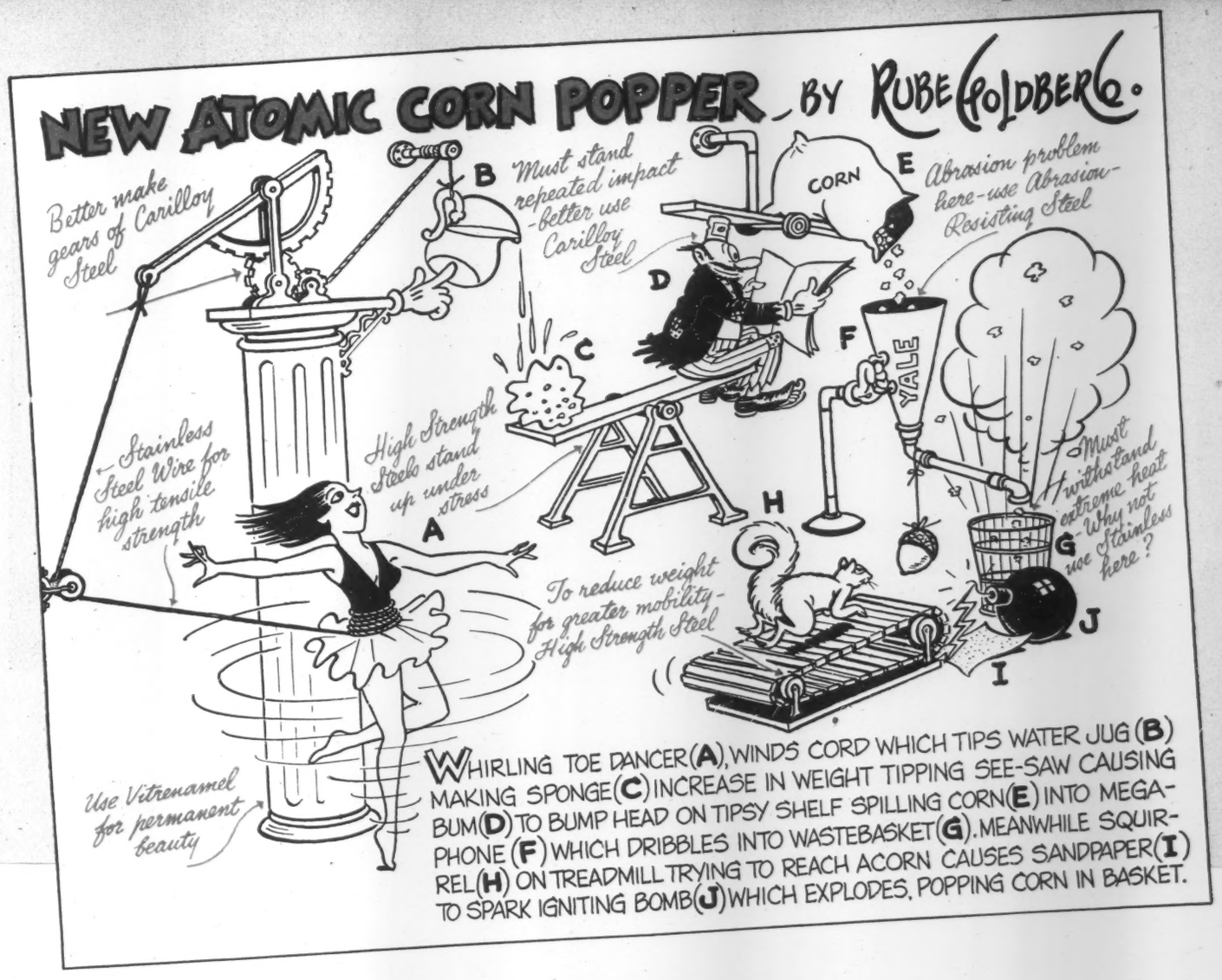



EVERYTHING FROM . . .

VALVES • FITTINGS
PIPE • PLUMBING
AND HEATING

# CRANE

FOR EVERY PIPING SYSTEM




● Even in such zany inventions as Mr. Goldbergs atomic corn poper shown above, it can be seen that, in nine cases out of ten, steel will do a job better. Not only better, but cheaper and quicker.

Better . . . because of its superior strength, hardness, toughness. Cheaper . . . because of steel's low cost and because steel can be fabricated easily on standard equipment found in most manufacturing establishments. Quicker . . . because it can be drawn, formed, forged, cast, machined on a mass production basis.

And steel offers still another advantage . . . it's available in a wide variety of grades and types. You'll find, if you check with our metallurgists, that there is always a type or grade that is exactly suited to the requirements of your application . . . that enables you to build your product better, cheaper, and quicker. Our experts are always ready to help you with any steel problem.

**CARNEGIE-ILLINOIS STEEL CORPORATION**

*Pittsburgh and Chicago*

Columbia Steel Company, San Francisco, *Pacific Coast Distributors*

Tennessee Coal, Iron & Railroad Company, Birmingham, *Southern Distributors*

United States Steel Supply Company, Chicago, *Warehouse Distributors*

United States Steel Export Company, New York

7-76

**Have you explored the possibilities of these special purpose U·S·S Steels?**

**U·S·S STAINLESS AND HEAT-RESISTING STEELS** to assure high resistance to corrosion and heat, and to reduce weight.

**U·S·S CARILLOY STEELS**—Alloy steels for the special jobs of industry.

**U·S·S HIGH STRENGTH STEELS** to resist atmospheric corrosion, to increase strength without adding weight or to maintain strength with reduced weight.

**U·S·S COPPER STEEL** to give at least twice the atmospheric corrosion resistance of regular steel at little additional cost.

**U·S·S ABRASION-RESISTING STEEL** to combat wear and friction.

**U·S·S HOT-ROLLED AND COLD-ROLLED STEELS** to provide the basic advantages of steel, plus maximum economy in each job.

**U·S·S PAINTBOND**—A galvanized, Bonderized sheet that permits immediate painting and holds paint tighter.

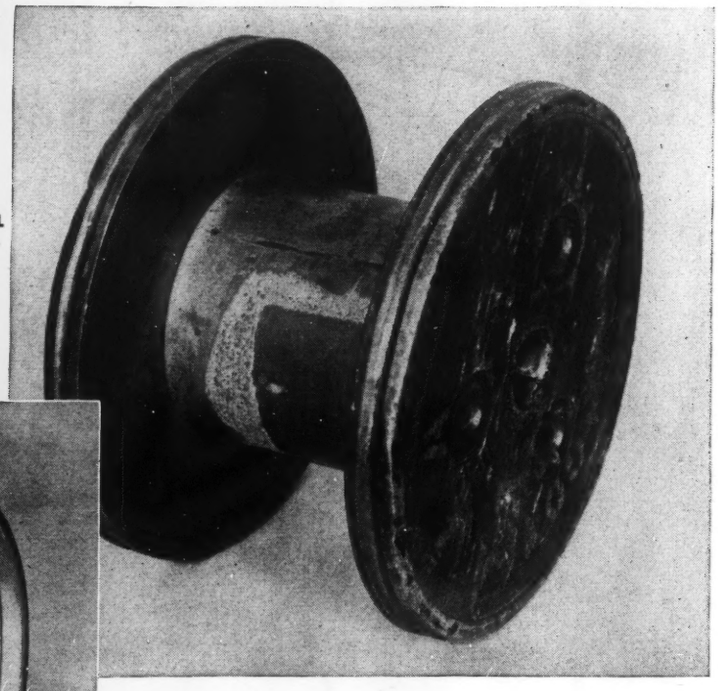
**U·S·S VITRENAMEL**—Sheets designed especially for porcelain enameling.

**U·S·S ELECTRICAL SHEETS** for motors, generators and transformers.

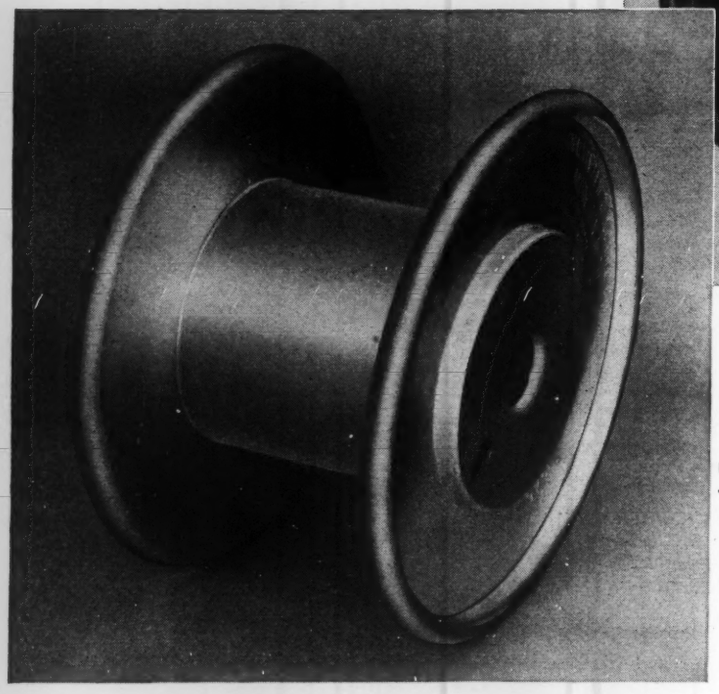
USS STEEL UNITED STATES STEEL

**9 times out of 10 STEEL will do it better**

UNITED STATES STEEL



OLD WOODEN SPOOL



NEW STEEL SPOOL

# CLEVE-WELD know-how

## CUTS WIRE SPOOL COSTS

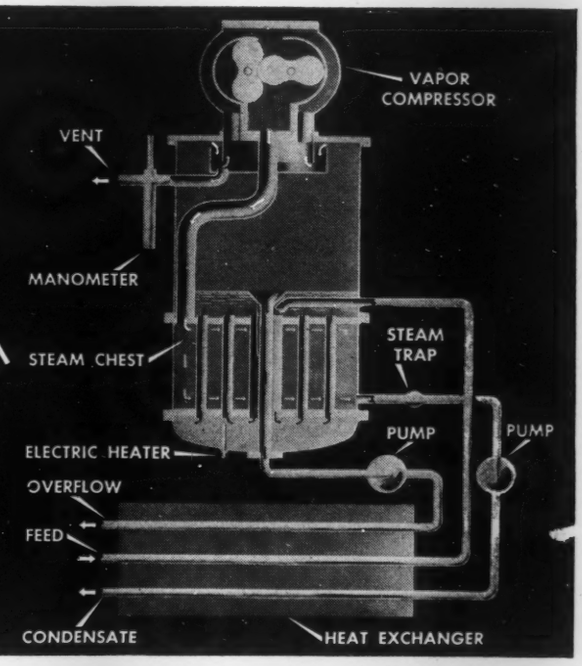
Specialized knowledge of circular welded steel technique enabled Cleve-Weld engineers to produce this new steel wire spool as a replacement for its wooden predecessor. These new steel spools are lighter and stronger, do not spread or give, hence, last three times as long as the wooden spools which makes a decided saving. They can be put in the furnace for drawing the wire to the right tensile strength.

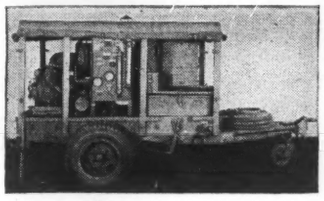
You, too, can save on circular shapes from Cleve-Weld—let us show you how! Send blueprints or description with specifications and let us quote on quantity lots. There's no obligation and we may be able to cut your costs —write today.

**THE CLEVELAND WELDING COMPANY**

West 117th Street & Berea Road • Cleveland 7, Ohio

# A Sketch of "STILL LIFE"



*Fifteen times more efficient than ordinary single-phase stills!* . . . That's how E. B. Badger and Sons, of Boston, Mass., describe their revolutionary Badger-Kleinschmidt vapor compression water still.

With a heat input of only 68 B.T.U. per pint, this compact, lightweight still can convert cold sea water into a running flow of pure fresh water.

But more than thermal efficiency was needed.

Resistance to salt water was a prime "must."

And, salt wasn't the only problem brought from the sea. Abrasive sand, grit and coral dust would have quickly ruined soft metals. So . . . hardness became another "must."

To counter corrosion and abrasion, the designers specified nickel alloys throughout. All sheet metal parts were made of a copper-nickel alloy. All bolts, nuts, studs, tie-rods, piping and fittings were made of Monel*.

Nickel alloys gave this still LIFE . . . *and something more.*

Because these alloys are strong, thinner sections of less weight could be used.

Because these alloys resist corrosion and oxidation, their clean surfaces provided rapid heat transfer.

★ ★ ★

***Solve your own metal selection problems*** with INCO Nickel Alloys. As a group they are strong, rustless, corrosion-resisting and hard. In addition, each offers individual properties to suit specific uses. . . . Write today for the free INCO METAL SELECTOR KIT.

**THE INTERNATIONAL NICKEL COMPANY, INC.** 67 WALL STREET, NEW YORK 5, N. Y.

**NICKEL** (INCO) **ALLOYS** MONEL* • "K"* MONEL • "S"* MONEL • "R"* MONEL • "KR"* MONEL • INCONEL* • NICKEL • "L"* NICKEL • "Z"* NICKEL

*Reg. U. S. Pat. Off.

*...the world's highest dams*

*...longest bridges*

# partners in creating

As the draftsman's pencil makes its mark, he issues orders, through a remarkable kind of shorthand, to the men who must act on his drawings. But only with special assistance can human hands shape such precise, complex orders as these. No wonder the draftsman chooses his instruments with care . . . he is, in effect, taking them into partnership!

In this sense, Keuffel & Esser Co. drafting equipment and materials have been the draftsman's partners for 80 years in creating the peaceful culture and wartime might of America, in making possible our concrete dams, steel bridges, aluminum bombers.

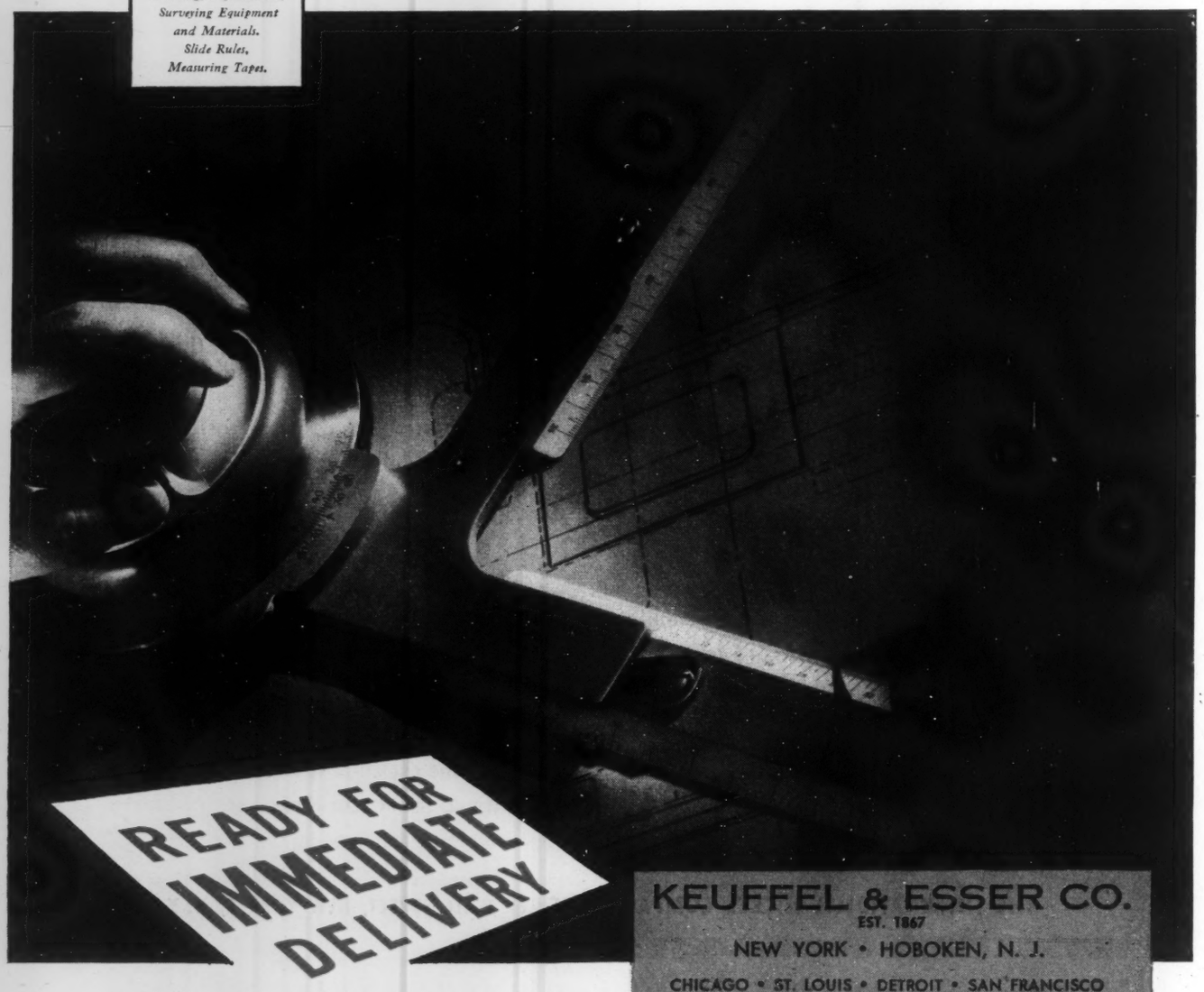
So universally is this equipment used, it is self-evident that every engineering project of any magnitude has been built with the help of K & E. Could you wish surer guidance than this in the selection of your "drafting partners"?

Especially in these hurried days, you will find a PARAGON* Drafting Machine a boon to your work . . . and your nerves! With the finger tips of your left hand on its control ring, the lightest pressure enables you to set the scales at any angle, anywhere on the board. Your right hand is always free. For the full PARAGON* story, write on your letterhead to Keuffel & Esser Co., Hoboken, N. J.

**Reg. U. S. Pat. Off.*

K+E

*Drafting, Reproduction, Surveying Equipment and Materials. Slide Rules, Measuring Tapes.*




KEUFFEL & ESSER CO.
EST. 1867
NEW YORK • HOBOKEN, N. J.
CHICAGO • ST. LOUIS • DETROIT • SAN FRANCISCO
LOS ANGELES • MONTREAL

*Factory-wired, conveniently packaged Reliance V★S Drive provides unlimited range of adjustable speeds for Diesel locomotive axle grinder . . . from A-c. circuits.*

RELIANCE V★S DRIVE

Whatever *your* product, whatever the machines used in making it, Reliance V★S Drive can increase the speed of production — and reduce your costs at the same time. V★S, the *All-electric, Adjustable-speed Drive operating from A-c. Circuits,* has done just this in many thousands of diversified applications.

Using A-c. power, the V★S Drive offers you unlimited flexibility of operation through automatic or manual control, either at the machine or from remote stations. Specifically, this means quick, smooth starts and stops, stepless speed changes, maintenance of proper tension and reversal at any desired point. Available in sizes from 1 to 200 horsepower. For more details of V★S operation, return coupon below today!

**RELIANCE ELECTRIC & ENGINEERING CO.**
**1079 Ivanhoe Road • Cleveland 10, Ohio**

Appleton, Wis. • Birmingham • Boston • Buffalo • Chicago • Cincinnati • Denver Detroit • Gary • Grand Rapids • Greenville, S. C. • Houston • Kansas City Knoxville • Los Angeles • Milwaukee • Minneapolis • New Orleans • New York Philadelphia • Pittsburgh • Portland, Ore. • Roanoke, Va. • Rockford • St. Louis San Francisco • Seattle • Syracuse • Tampa • Tulsa • Washington, D. C. Sao Paulo, Brazil

MAIL THIS COUPON TODAY!

**RELIANCE A-C D-C MOTORS**

*"Motor-Drive is More Than Power"*

**RELIANCE ELECTRIC & ENGINEERING CO.**
**1079 Ivanhoe Road, Cleveland 10, Ohio**

Please send your Bulletin 311 describing the operation and advantages of the Reliance V★S Drive.

NAME_____

COMPANY_____

TITLE_____

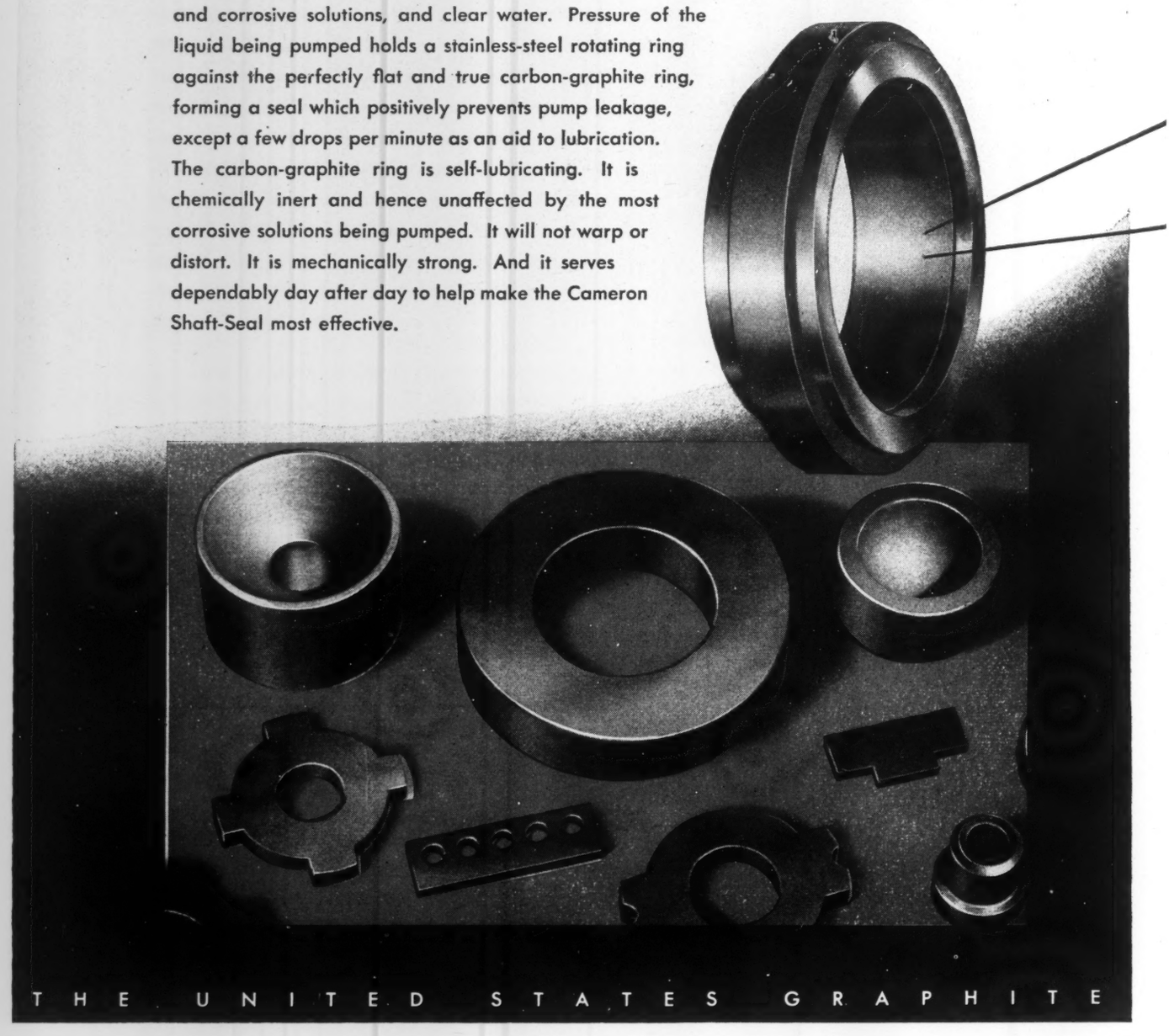
ADDRESS_____

CITY_____ ZONE_____ STATE_____

# graphitar (CARBON-GRAPHITE) seal ring on centrifugal

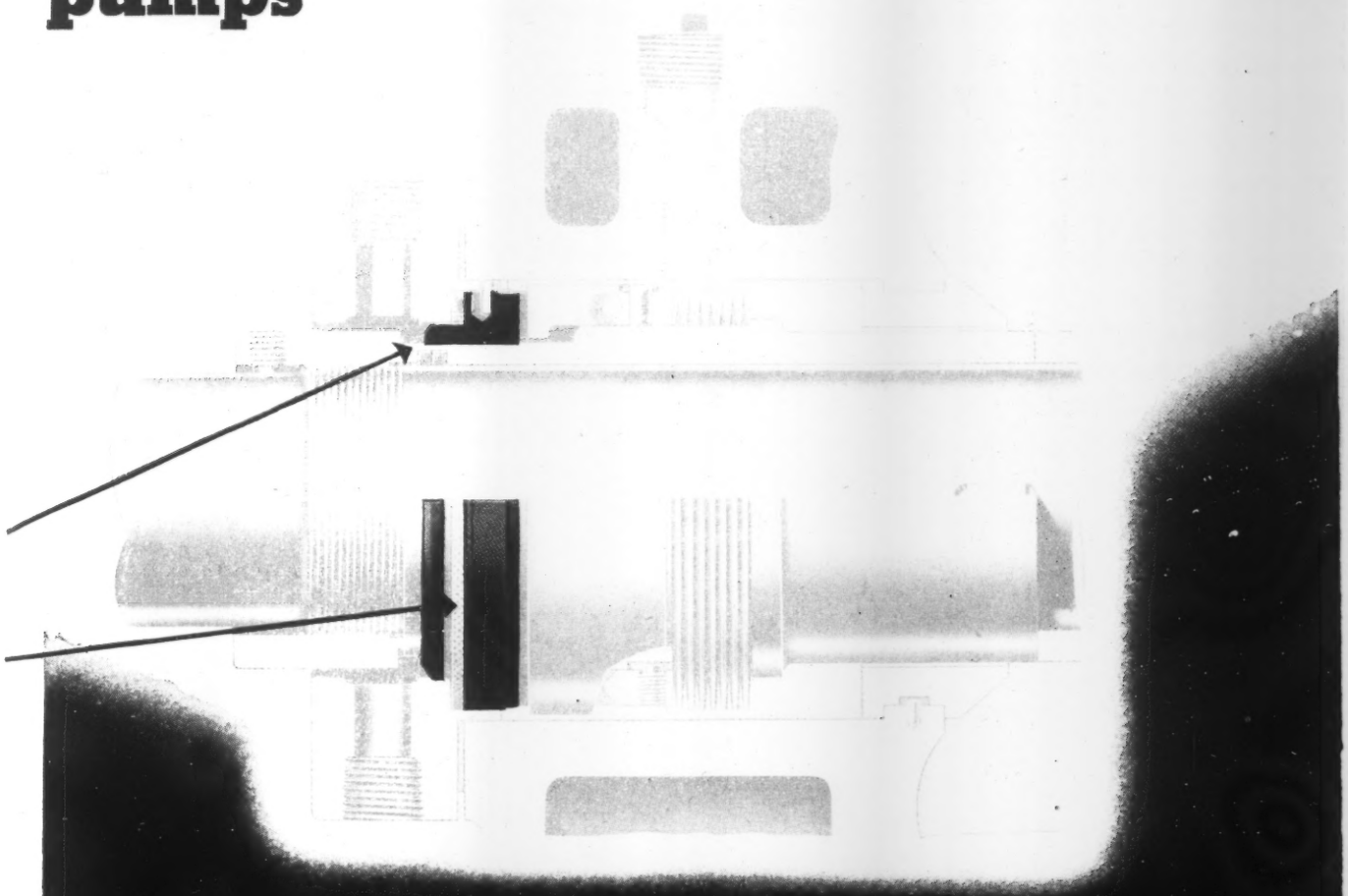
## Ingersoll-Rand's Cameron Shaft Seal, Which Prevents Leakage of Hot and Corrosive Fluids, Makes Use of a Carbon-Graphite Sealing Ring

The carbon-graphite stationary sealing ring is a vitally important part of the amazingly efficient Cameron Shaft-Seal made by Ingersoll-Rand to replace conventional stuffing-box packing on centrifugal pumps handling many types of hot and cold viscous fluids, highly volatile and corrosive solutions, and clear water. Pressure of the liquid being pumped holds a stainless-steel rotating ring against the perfectly flat and true carbon-graphite ring, forming a seal which positively prevents pump leakage, except a few drops per minute as an aid to lubrication. The carbon-graphite ring is self-lubricating. It is chemically inert and hence unaffected by the most corrosive solutions being pumped. It will not warp or distort. It is mechanically strong. And it serves dependably day after day to help make the Cameron Shaft-Seal most effective.



THE UNITED STATES GRAPHITE

# insures positive sealing pumps



## Graphitar Offers Advantages to All Industry

Graphitar—lightweight, strong, corrosion proof, unaffected by temperature extremes, self-lubricating—has proved itself of invaluable service to engineers and manufacturers in practically every industrial field. Graphitar cylinder liners shrunk fit in metal housings insure against leakage, seizing, and scoring in small steam engines, pumps, and gas compressors. Graphitar guide bearings align and support vertical shafts in sump pumps handling gasoline, alcohol, hot asphalt, salt brine, paint, and other corrosive liquids. Graphitar piston rings are standard in many non-lubricated compressors developing up to 2200 psi at 400°F. and 400 ft./min. Send us drawings or sketches of your products and our engineers will show you where Graphitar can improve mechanical performance and save you money.

C O M P A N Y • S A G I N A W , M I C H I G A N

# Two Sides to the Picture

## PRECISION GEAR DIVISION

"A-Q" Gears, engineered and produced in the Precision Gear Division of Foote Bros., offer manufacturers new possibilities in the field of power transmission.

Their application holds the solution to many problems where conditions demand extremely high speeds—where every ounce of excess weight must be eliminated—where utmost efficiency is required.

The Precision Gear Division also has complete research, metallurgical, engineering and manufacturing facilities to produce Power Units and Actuators, which provide control from a remote point, within an exacting time cycle. These units assure accurate mounting, so essential if the full benefit of "A-Q" Gears is to be realized. Originally developed for airplanes, Power Units and Actuators are also applicable on industrial or construction equipment where better control is required.

## INDUSTRIAL GEAR DIVISION

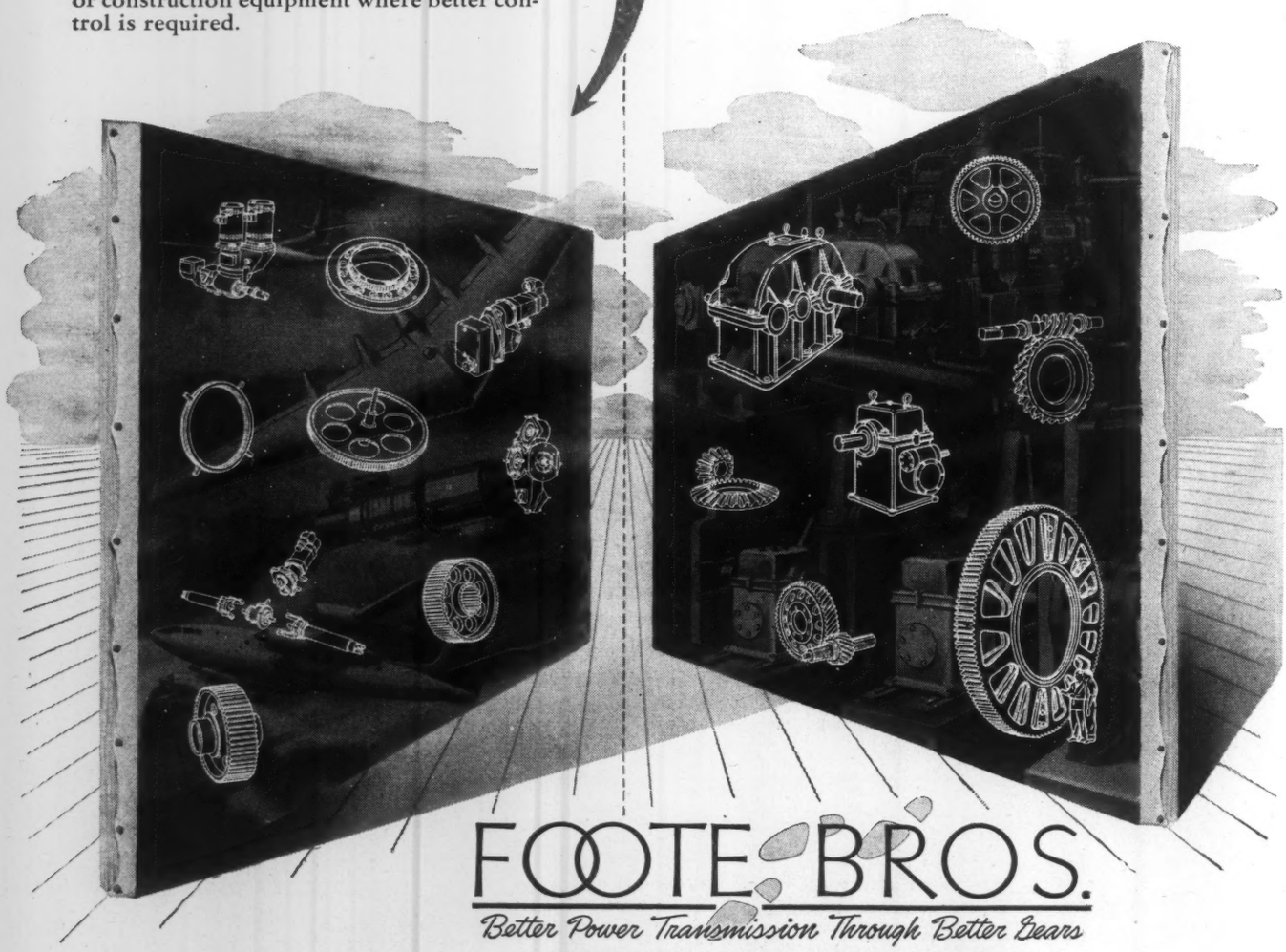
Nearly a century of experience is back of the power transmission equipment produced by the Industrial Gear Division of Foote Bros. This division offers a complete line of worm gear reducers and helical parallel shaft reducers in a wide range of ratios and sizes.

Many manufacturers also look to Foote Bros. to supply their needs for worm, helical, spur and bevel gears, completely manufactured from the original design to the finished gear. Sizes range from 16 D.P. up.

Foote Bros. gear cutting capacities include equipment capable of producing giant gears up to twenty feet in diameter for use on cement kilns and other large applications.

Still another phase of this company's operation is the construction of heavy machinery for locks, dams and bridges as well as special machinery built to specifications.

Regardless of what your requirement in the field of power transmission equipment may be, Foote Bros. will be glad to discuss the problem with you.



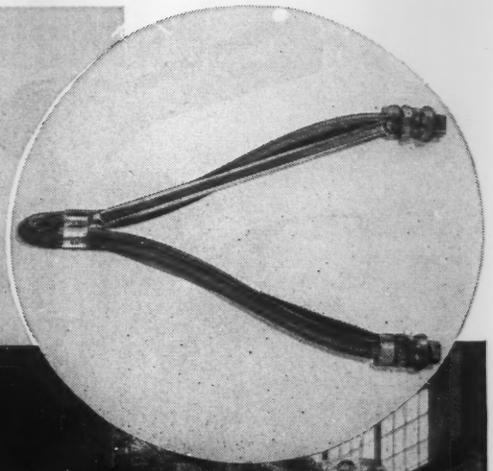
FOOTE BROS.

*Better Power Transmission Through Better Gears*

**FOOTE BROS. GEAR AND MACHINE CORPORATION**

Dept. O, 4545 South Western Boulevard • Chicago 9, Ill.

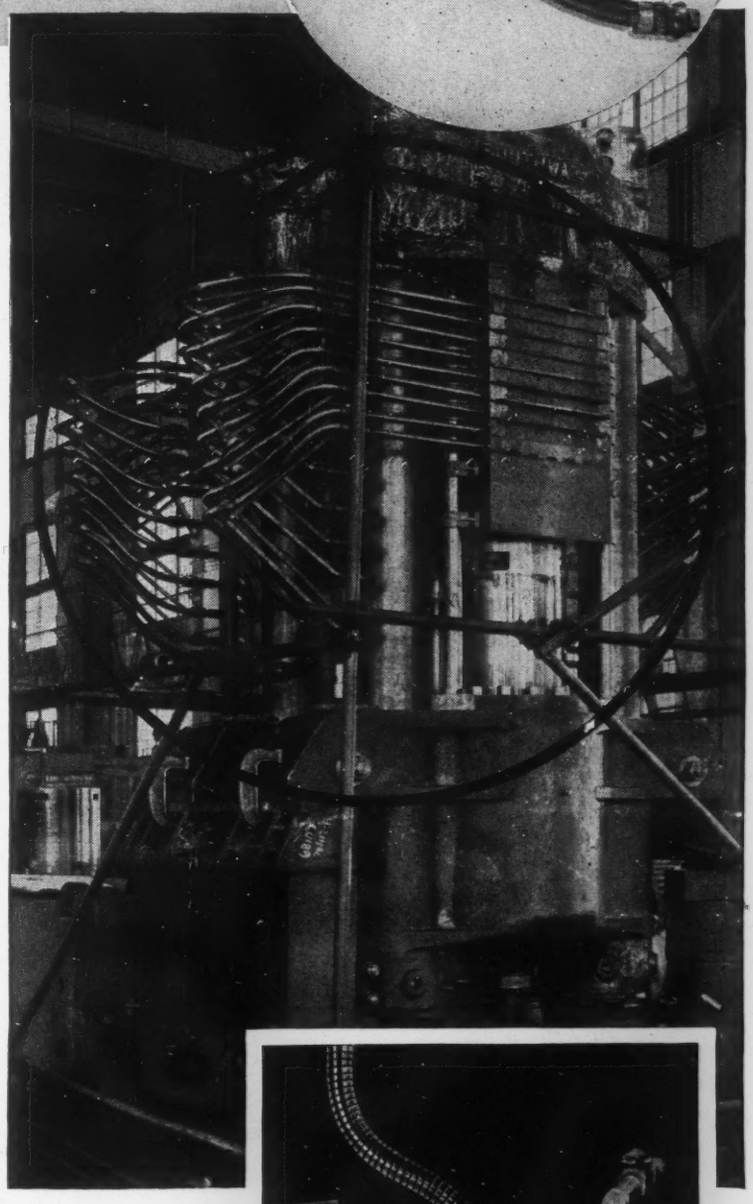
# *Metal Hose*
## puts the heat on plastics



IN THE HUGE Baldwin Southwark platen press illustrated here, 36 American Bracketubes* insure steam delivery without leaks, without binding swing joints and down time for repacking. Because of their exceptional flexibility, Bracketubes permit platens to move freely. Properly installed, no condensate collects in the lines when the press is not operating.

American Bracketubes are but a single example of the complete range of specialized connectors available in American Flexible Metal Hose and Tubing. Wherever connections must be made between moving or misaligned parts, wherever fluids or gases, hot or cold, must be conveyed under pressure or around bends or both, an American connector will meet the most exacting requirements with economy and long service. For detailed information or technical assistance on your problems, write for literature. 40355

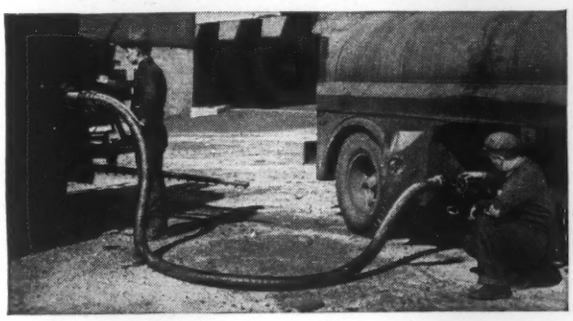
*Patented

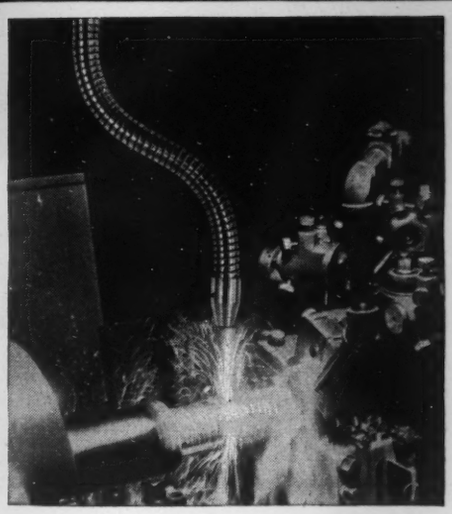


ANACONDA
from mine to consumer

*American*
**METAL HOSE**

**THE AMERICAN BRASS COMPANY**
***American Metal Hose Branch***
General Offices: Waterbury 88, Connecticut
*Subsidiary of Anaconda Copper Mining Company*
*In Canada:* ANACONDA AMERICAN BRASS LTD.,
*New Toronto, Ont.*





*Left:*
*Transferring road oil in Type BD 15 Interlocked Flexible Steel Oil Hose. Available in sizes ½ to 12 inches I.D., for conveying oils, grease, tar, asphalt, other liquids and semi-solids.*

*Right:*
*American Flexible Oil Feed and Coolant Lines stay put when bent and direct a continuous flow of cutting oil exactly as required.*

# *Every Drop Cleaned*

## EVERY MINUTE ON THE JOB

### *Select Cuno Auto-Klean Filter for Continuous Cleaning of Full Flow*

This *one* fluid-cleaning unit — no larger than the usual partial-flow type — handles *full flow* of practically any fluid.

The permanent all-metal, disc-type filtering cartridge removes *all* particles down to .0035″.

And the exclusive "comb-action" filter cleaning removes accumulated solids *without* interrupting flow.

**BUILT-IN OR EXTERNALLY MOUNTED**

Cuno Auto-Klean Filters are available with or without sumps for built-in or external installations. Sizes from 1¼″ x ⅞″ cartridge to massive motor-driven models to handle a few gallons per hour or millions of gallons per day. Filters cleanable manually (by turning handle) or automatically.

*For fluids containing highly abrasive solids* —Cuno Flo-Klean, wire-wound permanent cartridge, continuously cleanable by motor-driven backwash system.

Write us to have the local Cuno representative recommend proper Cuno filter (see below) for your fluid-cleaning application.

**See Catalog in SWEET'S**

SEND COUPON FOR FREE FACTS TO FIT YOUR INSTALLATION

**CUNO ENGINEERING CORPORATION**
**207 South Vine St., Meriden, Conn.**

Please have nearest Cuno representative provide information relative to services checked.

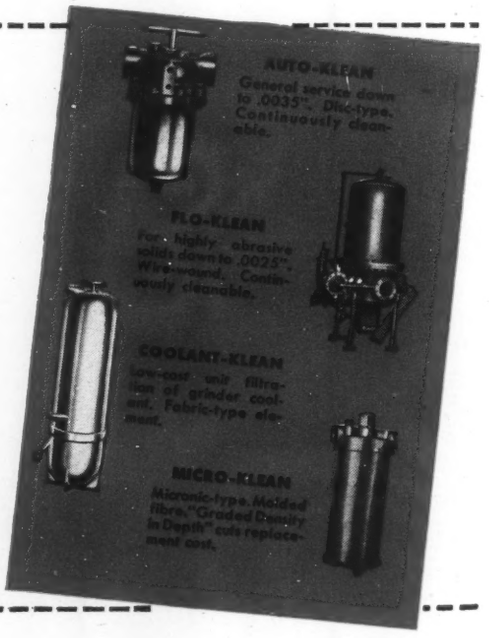
- ☐ Air Actuated Instruments
- ☐ Air Tools
- ☐ Bakery Machinery
- ☐ Balers
- ☐ Blowers
- ☐ Boiler Feed
- ☐ Coal Loaders
- ☐ Coating Machinery
- ☐ Combustion Equipment
- ☐ Compressors
- ☐ Controls
- ☐ Cooling Systems
- ☐ Crushers
- ☐ Diesel Engines
- ☐ Dip Tank Systems
- ☐ Drilling Machines
- ☐ Engines
- ☐ Gear Hobbing Machines
- ☐ Grinders
- ☐ Hobbing Machines
- ☐ Honing Machines
- ☐ Hydraulic Systems
- ☐ Incubators
- ☐ Instruments
- ☐ Lathes
- ☐ Lubricating Systems
- ☐ Machine Tools
- ☐ Meters
- ☐ Milling Machines
- ☐ Oil Burners
- ☐ Oil Well Drilling Equipment
- ☐ Paint Spray Systems
- ☐ Paper Machinery
- ☐ Pneumatic Devices
- ☐ Power Transmissions
- ☐ Presses
- ☐ Printing Presses
- ☐ Pumps
- ☐ Radial Drills
- ☐ Rolling Mills
- ☐ Scrap Balers
- ☐ Spray Systems
- ☐ Superchargers
- ☐ Tapping Machines
- ☐ Test Stands
- ☐ Turbines
- ☐ Turret Lathes
- ☐ Welding Machines

*Name* .....

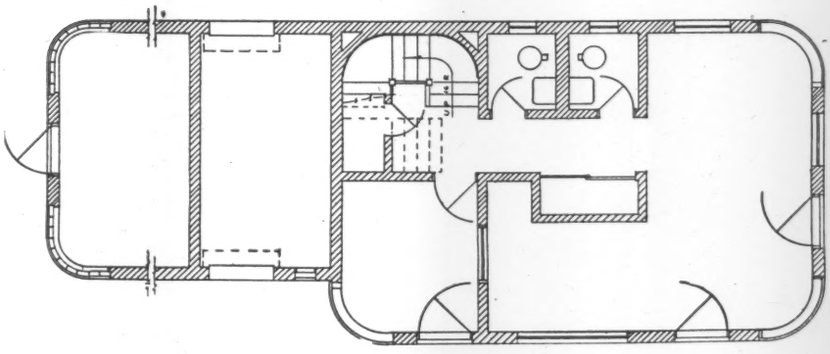
*Company* .....

*Address* .....

*Title* .....



# Save time, labor, materials with these short cuts in drafting!



### 1. UNNECESSARY DRAFTING ELIMINATED

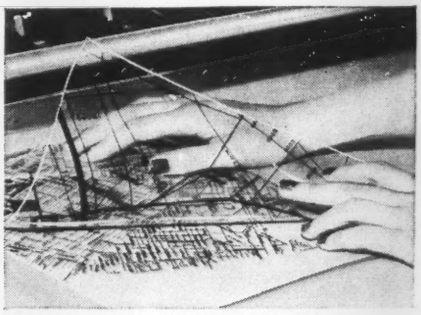
Assume that you want additional tracings of the above floor plan so that you can add the plumbing layout to one copy, the air-conditioning layout to the next, and so on.

With Ozalid, you need never redraw your original tracing! Just make translucent Ozalid Intermediate prints of it . . . and on these, add the individual details in pencil or ink. Then from each "Intermediate" you can produce the desired number and type of positive OZALID PRINTS.

This is just one example that probably suggests dozens of uses for Ozalid in your everyday work!

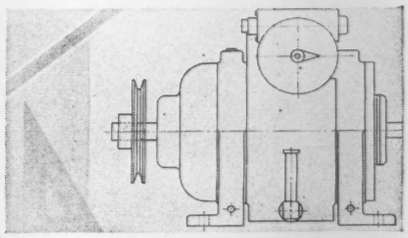
### 2. SEPARATE DESIGNS COMBINED

The extreme transparency of Ozalid foil permits the production of composite prints, which are generally made to show the relationship of separate design details to each other.

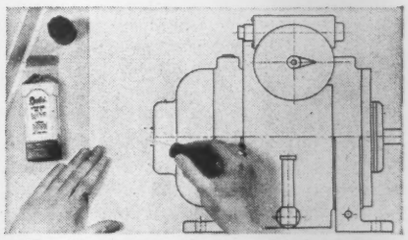


To do this, you merely make a foil print of each tracing . . . then overlay the foils in the desired position on Ozalid sensitized material . . . and feed into your Ozalid machine.

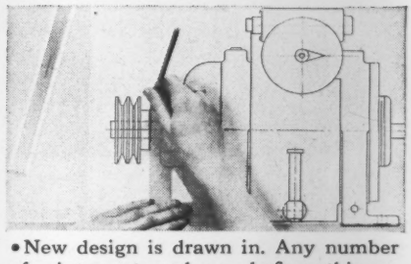
### 3. OBSOLETE DETAILS REMOVED



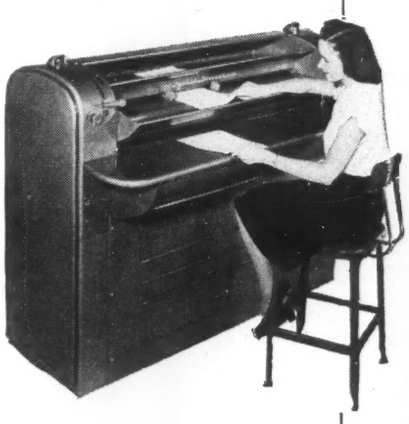
• This is an Ozalid Intermediate (translucent) print of the original drawing.



• Draftsman eradicates obsolete lines with quick-drying OZALID CORRECTOR FLUID.



• New design is drawn in. Any number of prints can now be made from this up-to-date "Master."



**SEE the 10 different types of Ozaprints you can make. *Learn* all about the new Ozalid Streamliner! Write today for free booklet No. 235.**

## NEW OZALID STREAMLINER

***. . . Designed for Average Printmaking Requirements!***

This completely new, moderately priced machine gives you these five extra values in *printmaking* at no extra cost—

**Efficiency:** You get positive (not negative) prints direct from your tracings in *two* simple steps: Exposure and Dry Development.

**Speed:** Your prints are delivered completely dry, ready for use in only 25 seconds.

**Economy:** An 8½ x 11" print costs one cent; 11 x 17", two cents. You can make prints up to 42 inches wide, any length. Your Streamliner requires only 11 sq. feet of floor space.

**Versatility:** The lines and images on your originals can be reproduced in black, blue, red, sepia, yellow . . . on paper, cloth, foil, film, or plastic. All prints are made in *same manner* . . . simply choose type of Ozalid material best for job at hand.

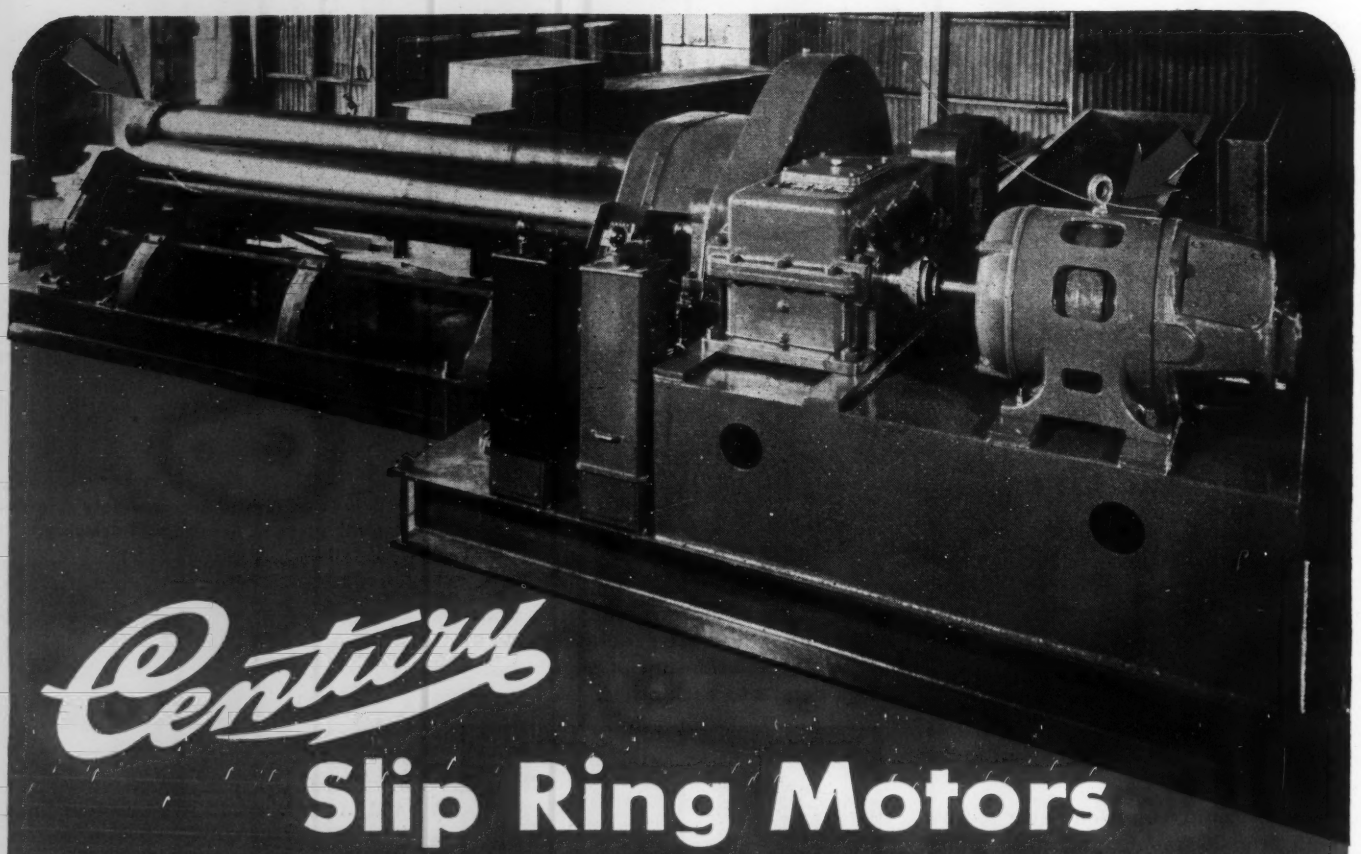
**Simplicity:** Anyone can be the operator. Prints are delivered on top, stacked in order, within easy reach.

# OZALID

**DIVISION OF GENERAL ANILINE AND FILM CORPORATION**

**Johnson City, N. Y.**

**Ozalid in Canada—Hughes Owens Co., Ltd., Montreal**



# Century Slip Ring Motors

## Provide Maximum Performance for Bending Rolls

- **Varying Torque**
- **Speed Regulation**
- **Low Starting Current**

In the installation shown here two Century Slip Ring Motors have been correctly applied. A 20 horsepower Slip Ring Motor drives the plate rolls and a 7½ horsepower motor raises and lowers the rolls to regulate the curvature of the plate that is bent.

These motors have the ability to start heavy loads with a minimum of starting current and the speed of the motor may be controlled to compensate for varying thicknesses of metal plate.

Another advantage of Slip Ring Motors is that the direction of rotation may be readily reversed when application requirements make it necessary.

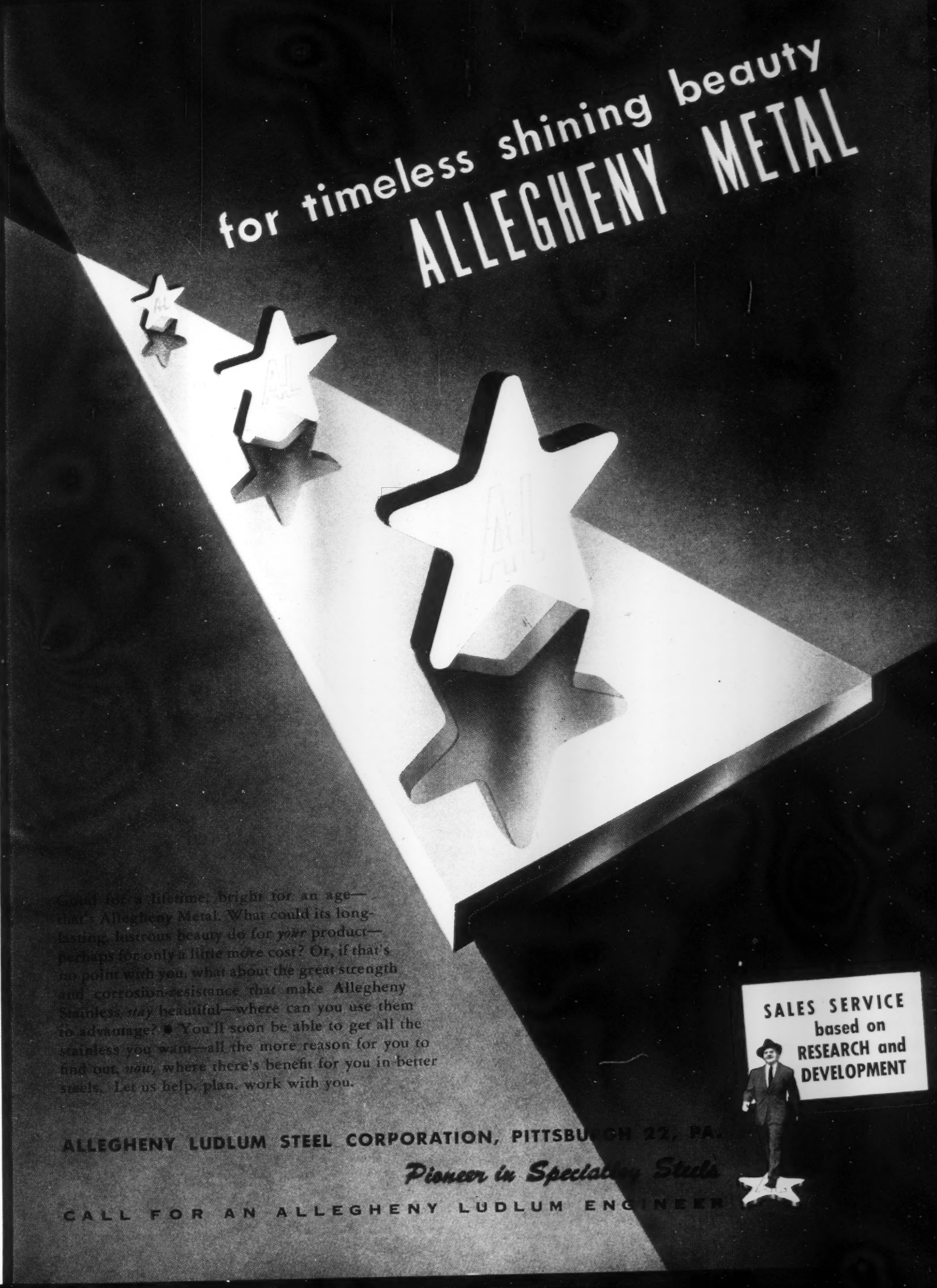
Century motors are built in a wide variety of types, in sizes from 1/6 to 400 horsepower to meet nearly every electric power requirement. Century motors are engineered to the requirements of the machines they drive to assure top performance. Specify Century for all your electric motor requirements.

Century C MOTORS

504

**CENTURY ELECTRIC COMPANY** · 1806 Pine St., St. Louis 3, Mo.

*Offices and Stock Points in Principal Cities*


for timeless shining beauty
ALLEGHENY METAL
Good for a lifetime, bright for an age—that's Allegheny Metal. What could its long-lasting, lustrous beauty do for *your* product—perhaps for only a little more cost? Or, if that's no point with you, what about the great strength and corrosion-resistance that make Allegheny Stainless *stay* beautiful—where can you use them to advantage? ● You'll soon be able to get all the stainless you want—all the more reason for you to find out, *now*, where there's benefit for you in better steels. Let us help, plan, work with you.
SALES SERVICE based on RESEARCH and DEVELOPMENT
ALLEGHENY LUDLUM STEEL CORPORATION, PITTSBURGH 22, PA.
Pioneer in Specialty Steels
CALL FOR AN ALLEGHENY LUDLUM ENGINEER

# *An Instrument of Tomorrow*

**BETTER INSIDE ... BETTER OUTSIDE ... BETTER ON THE FACE OF IT**

*.... Here Today*

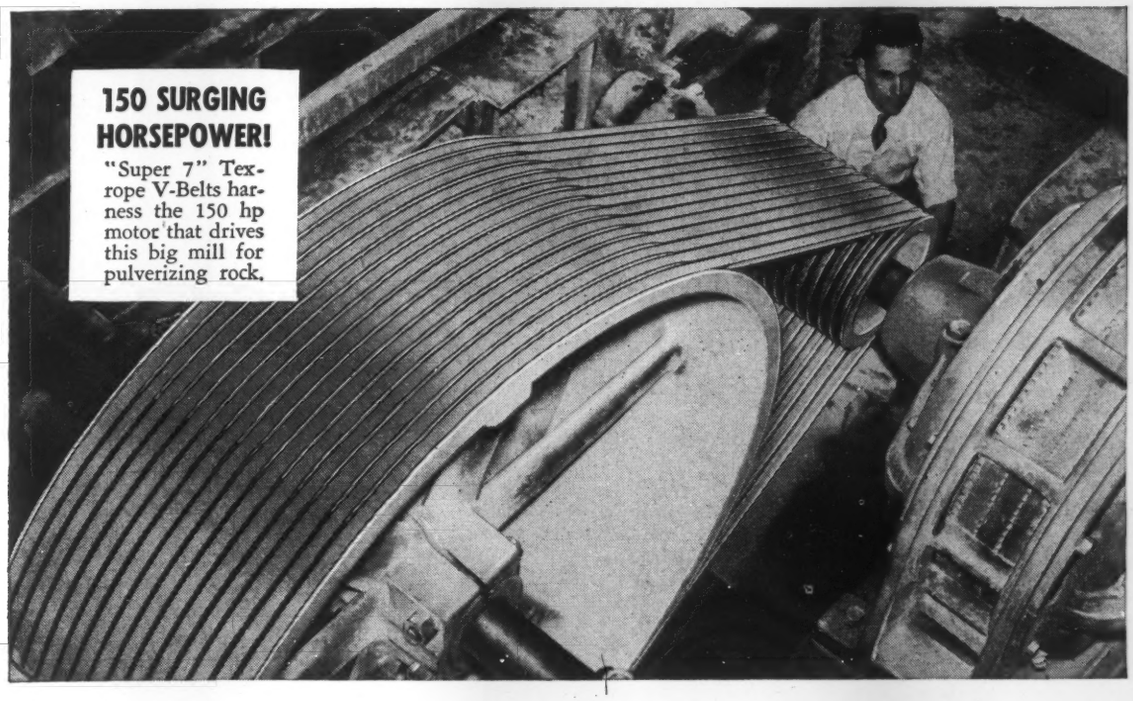
U. S. INSTRUMENTS Tell The Truth

# UNITED STATES GAUGE

***THE NEW USG SUPERGAUGE***—is an instrument of test gauge accuracy, a gauge specially designed for long years of service in industrial installations where excessive vibration, pulsation and high temperature are present. It provides the safe, accurate, economic check on process control that engineers demand. Modernly styled, it has clean trim lines and an easy-to-read broad face dial with bold sharp figures and graduations. Furnished in 4½", 6", and 8½" dial sizes. Buy reasonably priced Supergauge today.

*DIVISION OF AMERICAN MACHINE AND METALS, INC. SELLERSVILLE, PA.*
*Manufacturers of Pressure, Temperature, Flow and Electrical Measuring Instruments*

USG

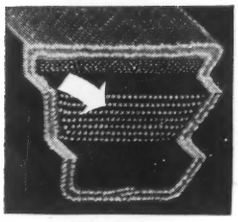


**150 SURGING HORSEPOWER!**

"Super 7" Texrope V-Belts harness the 150 hp motor that drives this big mill for pulverizing rock.

# PULLING POWER

## . . . one of the 7 Great Features in "Super 7" Texrope V-Belts!



1. **STRONGER CORDS** give "Super 7" Texrope V-Belts their great pulling power. These long-fibre, hard-twisted cotton cords have the strength of high-test fish lines. Laid row on row and imbedded in heat resistant rubber compound, they provide a powerful load-carrying element.

2. **TOUGHER COVER.** Rugged duplex construction protects the carcass of "Super 7" belts from wear and dirt.

3. **HEAT RESISTANCE.** *All* "Super 7" V-Belts are designed and built to give high resistance to heat.

4. **SHOCK ABSORBING.** "Super 7" construction combines great strength with the degree of resiliency necessary for long belt life and smooth power transmission.

5. **PRECISION CURED** in pressure molds to assure accurate section and perfect bonding of cords, cover and cushion.

6. **ACCURATELY MATCHED.** Every belt weighed, measured and carefully inspected before being sized and packed.

7. **ENGINEERING LEADERSHIP.** "Super 7" Texrope V-Belts represent 27 years of research and experience — by Allis-Chalmers, originator of the Multiple V-Belt Drive.

• • •

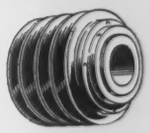
There are FIVE types of "Super 7" Texrope V-Belts, to meet every operating requirement: *Standard — Heat Resisting — Oil Resisting — Oil Proof* — and *Static Resisting*. Call your Allis-Chalmers office or dealer. ALLIS-CHALMERS, MILWAUKEE 1, WIS.

A 2161

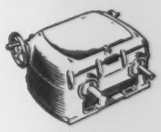
## TEXROPE .. Greatest Name in V-Belt Drives

**"Super 7" V-BELTS**
Five Types — Sizes to suit every power transmission job.

**Texsteel, Texdrive, "Magic-Grip"**
— sheaves in a full range of sizes, grooves.



**"Vari-Pitch" SHEAVES**
Exact variations in speed, stationery or motion control.



**SPEED CHANGERS**
Speed variations up to 375% at the turn of a crank.

**ENGINEERING**
Finest V-Belt engineering talent in the world—at your call.

TEXROPE "Super 7" V-Belts result from the cooperative research of two great companies — Allis-Chalmers and B. F. Goodrich. They are sold only by A-C.

# ALLIS-CHALMERS

**One of the Big 3 in Electric Power Equipment — Biggest of All in Range of Industrial Products**

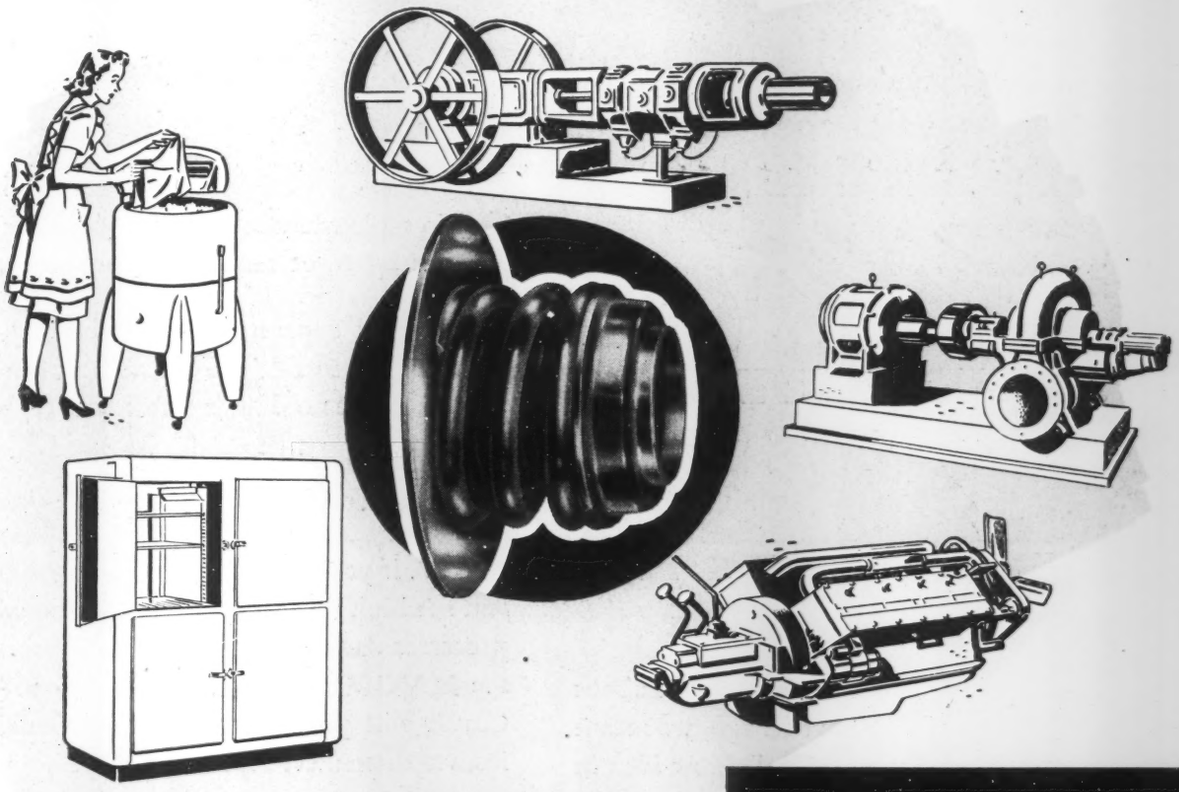
1847 1947
A CENTURY OF SERVICE to Industry THAT MADE America Great

The exclusive Hannifin Sensitive Pressure Control used for straightening and assembly operations gives the operator complete control of ram movement and working pressure at a finger-tip touch. The result is smooth, fast, accurate handling of work and increased production.

Straightening presses—standard models from 6 to 150 tons; Forcing presses from 5 to 150 tons; Four column types. Wide range of standard designs available, with ram speeds to suit operating needs. Write for press bulletin. Engineering service available in all industrial centers.

Hannifin Manufacturing Company, Chicago 24.

**HANNIFIN hydraulic PRESSES**



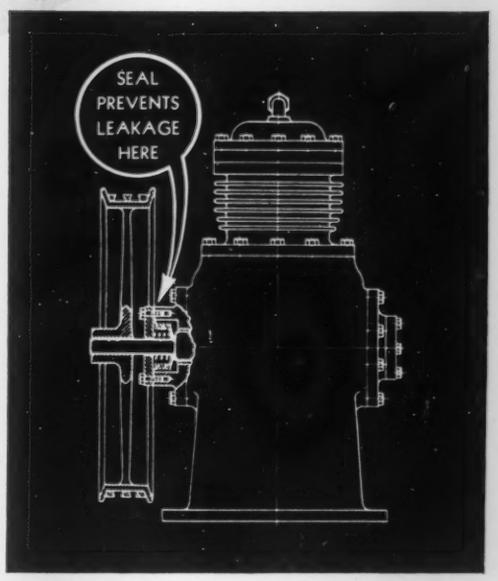
# STOP SHAFT SEEPAGE
## with a Sylphon Seal

FACED with the problem of sealing a rotating shaft against the seepage of gas or liquid? Solve it quickly, easily, at low cost with a Sylphon Seal.

Engineered only on order for specific applications, Sylphon Shaft Seals withstand pressures up to hundreds of pounds, operate at speeds as high as 400 RPM.

Here's how they work: A seal nose, made of anti-friction bearing material, is held firmly against the shaft collar by a thrust spring—while mounted on a flange is a Sylphon bellows which maintains a leak-proof, trouble-free connection between the flange and the seal nose.

Widely and successfully used in compressors, pumps, washing machines, hydraulic transmissions and a wide variety of other applications. Sizes for shafts 1/16" diameter and up. Catalog EK 825 tells all. Write for copy today.




*Typical use of a Sylphon Seal in a refrigerator compressor. Applications requiring special designs carefully considered.*

FS

FIRST WITH BELLOWS

THE FULTON SYLPHON CO. KNOXVILLE 4, TENN.

**FULTON SYLPHON**

*Temperature Controls · Bellows · Bellows Assemblies*

*Canadian Representatives, Darling Brothers, Montreal*

# "MAXITORQ" IS *Profit* TALK TO CLUTCH USERS

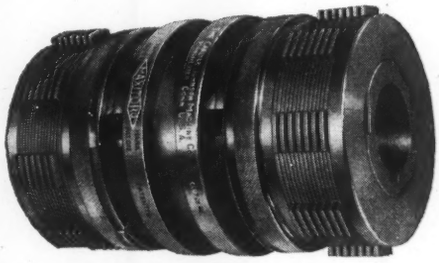
When we first talked about CLUTCHES, more than 40 years ago, we meant the "Johnson" . . . then a basically new idea in clutch construction. It was a fine clutch at that time, as it is today.

But the **"MAXITORQ",** our present model is the culmination of all those years of trying to do just one thing . . . build the most positive, dependable, compact means for power transmission that could be devised.

Many leading machine designers tell us we have accomplished this purpose with the Maxitorq . . . and are proving it with their continuing orders. Here are some of their reasons for Maxitorq preference:

1. The Maxitorq comes in one compact unit . . . ready to slip on a shaft.
2. No tools whatsoever are required to adjust, take apart, or reassemble the clutch.
3. Patented Separator Springs hold the discs apart in neutral (you can see between them). Therefore no drag, no abrasion, no heating.
4. Disconnect is fast, positive. No slipping from neutral.

And . . . if you have a power transmission problem for high speed, automatic machinery which processes damageable or breakable products . . . the **MAXITORQ** Automatic Overload Release Clutch will positively answer all demands for instant disconnect and full safety.



**STANDARD MAXITORQ, DOUBLE TYPE**

STANDARD MAXITORQ made in single and double types, wet or dry, from ¼ to 15 h.p. at 100 rpm. OVERLOAD RELEASE MAXITORQ made in single type, ¼ to 5 h.p. at 100 rpm. PULLEY and CUT-OFF COUPLING types also available.

***A new publication, giving complete engineering data has just been printed.***

**SEND FOR CATALOG NO. MD3 TODAY.**

**THE CARLYLE JOHNSON MACHINE COMPANY**
MANCHESTER • CONNECTICUT

# SUPERIOR ABRASION RESISTANCE

Parts made from HYCAR synthetic rubber have 50% greater abrasion resistance than parts made from natural rubber. That means they'll last longer, give more dependable performance in the most severe service, and save maintenance and replacement time.

But that's only one of HYCAR's unusual and valuable properties. Examine the list in the box at the right. Think of these properties in terms of your requirements of rubber parts. Realize that these properties may be had in an almost limitless number of combinations, each designed to meet the specific service conditions of the finished part.

We have developed more than 5000 recipes for HYCAR compounds — each compound engineered to do a certain job. If you're looking for rubber parts that will give long life, dependability, and economical operation, *specify HYCAR.*

Ask your supplier for parts made from HYCAR. Test them in your own applications, difficult or routine. You'll learn for yourself that it's wise to use HYCAR for long-time, dependable performance. For more information, please write Department HN-3 B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio.

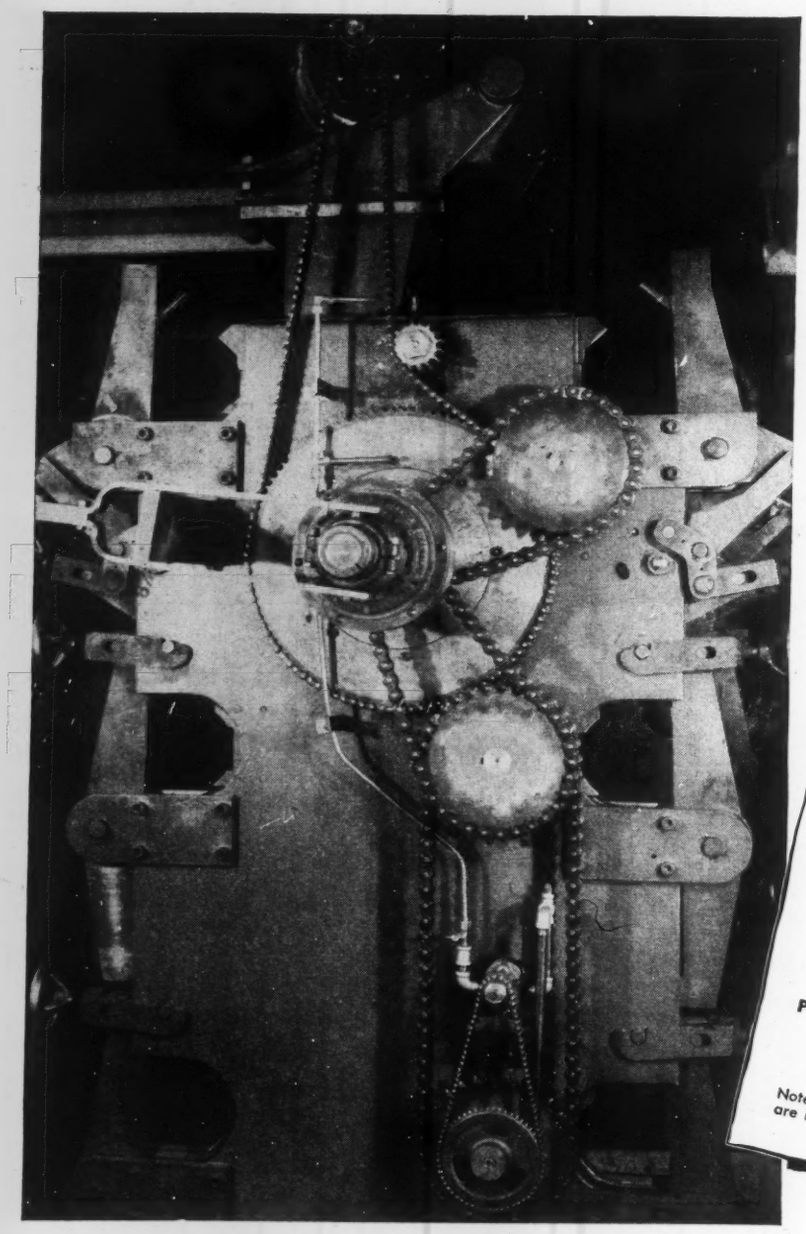
**CHECK THESE SUPERIOR FEATURES OF HYCAR**

1. *EXTREME OIL RESISTANCE — insuring dimensional stability of parts.*
2. *HIGH TEMPERATURE RESISTANCE—up to 250° F. dry heat; up to 300° F. hot oil.*
3. *ABRASION RESISTANCE—50% greater than natural rubber.*
4. *MINIMUM COLD FLOW—even at elevated temperatures.*
5. *LOW TEMPERATURE FLEXIBILITY—down to —65° F.*
6. *LIGHT WEIGHT—15% to 25% lighter than many other synthetic rubbers.*
7. *AGE RESISTANCE—exceptionally resistant to checking or cracking from oxidation.*
8. *HARDNESS RANGE—compounds can be varied from extremely soft to bone hard.*
9. *NON-ADHERENT TO METAL—compounds will not adhere to metals even after prolonged contact under pressure. (Metal adhesions can be readily obtained when desired.)*

**Hycar**
Reg. U. S. Pat. Off.
*American Rubber*

**B. F. Goodrich Chemical Company**
A DIVISION OF THE B. F. GOODRICH COMPANY

**GEON polyvinyl materials • HYCAR American rubber • KRISTON thermosetting resins • GOOD-RITE chemicals**



# Driving Multiple-Barrel Rattler

## *Illustrates Ease of Coordinating Many Motions*

***Here are the details:***

**MOTOR DRIVE:**
Motor Drive Sprocket . . . . . 16 Teeth
Driven Sprocket . . . . . 100 Teeth
Chain—No. 148 Chain Double, 188 pitches

**TOP BARREL DRIVE:**
Drive Sprocket . . . . . 13 Teeth
Driven Sprocket . . . . . 29 Teeth
Chain—No. 434 Single . . . . . 23 pitches

**CENTER BARREL DRIVE:**
Drive Sprocket . . . . . 13 Teeth
Driven Sprocket . . . . . 29 Teeth
Chain—No. 434 Single . . . . . 25 pitches

**LOWER BARREL DRIVE:**
Drive Sprocket . . . . . 29 Teeth
Driven Sprocket . . . . . 29 Teeth
Chain—No. 434 Single . . . . . 39 pitches

**PUMP DRIVE:**
Drive Sprocket . . . . . 53 Teeth
Driven Sprocket . . . . . 15 Teeth
Chain—No. 82 Single . . . . . 46 pitches

Note: Drives on opposite side of machine, excepting motor, are identical in relative position to those listed.

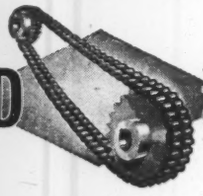
## *With DIAMOND Roller Chain Drives*

Six tumbling barrels for cleaning small parts are all driven from one motor—economically, by DIAMOND Roller Chain Drives. As positively driven as with gears—speed ratios and direction of shafts travel as desired—all motions coordinated.

Imagine the number of gears and shafts—the added weight and cost—that an all-gear drive of this machine would entail.

In many cases it can be said that without Diamond Chains it would be difficult if not impractical to arrive at an acceptably designed machine.

The many opportunities for product improvement and simplification that Diamond Roller Chain Drives offer, recommend them for *your* serious consideration now. DIAMOND CHAIN COMPANY, Inc., Dept. 435, **402** Kentucky Avenue, Indianapolis 7, Indiana. *Offices and Distributors in All Principal Cities.*

**DIAMOND**  **ROLLER CHAINS**

The drive data in our 96-page Bulletin 617 will help you. A copy is yours for the asking.

*Bronze bushings of two types, cast centrifugally and precision-finished by Shenango-Penn. These and other shapes, many far more complex, are regularly produced here for reasons outlined below.*

# IT'S A BETTER PLAN.. if Shenango-Penn Centrifugally Cast Parts are in it!

**HERE'S WHY!** Parts cast centrifugally by Shenango-Penn, and machined by us too, if you wish, are inherently much stronger and tougher, have finer, more uniform grain structure than ordinary cast parts of the same analysis. Centrifugal pressure gives the metal greater density, raises Brinell hardness 2 to 5 points, increases tensile strength by 8 to 20 per cent. At the same time, the Shenango-Penn process prevents sand inclusions, blow holes, porosity.

Those are a few of the reasons why more and more builders of machinery and equipment are turning to Shenango-Penn for all castings and parts that are essentially symmetrical in shape. It's a flexible process, not by any means limited to parts of simple circular section. Many variations are possible including flanges, bosses, lugs and other projections.

Yes, any product plan that includes Shenango-Penn castings instead of ordinary ones is indeed a *better* plan. It always means a more durable product, better able to withstand pressure, friction, abrasion, corrosion and all kinds of stresses. It also means lower production cost. Don't you think it's worth looking into?

**Bulletin No. 143 gives full information on Shenango-Penn centrifugal castings including specifications and analyses of the various alloys available, and also tells about our modern machining facilities for those users who desire semi-machined or finished parts. Send for this free bulletin.**

SHENANGO-PENN

**SHENANGO-PENN MOLD COMPANY**
**1263 West Third Street · Dover, Ohio**
***Executive Offices:* Pittsburgh, Pa.**

**ALL BRONZES • MONEL METAL • ALLOY IRONS**

# The NEW "SK" MICRO *Precision* Lightweight . . . Small Size

**SIZE**
Extremely Compact and Light Weight. Switch unit only 1 3/16 inches.

**CAPACITY**
High Capacity—10 amperes, 110 volt and 5 amperes, 220 volt A. C.

**ACTUATION**
Constructed to lend itself to varied actuation by cam, slide or "in line" motion.

**SPECIAL CIRCUITS**
Special circuits can be accommodated by use of bus bars on ganged units.

**CIRCUIT CHOICE**
"SK" switches are made in normally open, normally closed, and double throw circuit arrangements.

**OPERATING FORCE**
3—8 oz.

**RELEASE FORCE**
2½—7 oz.

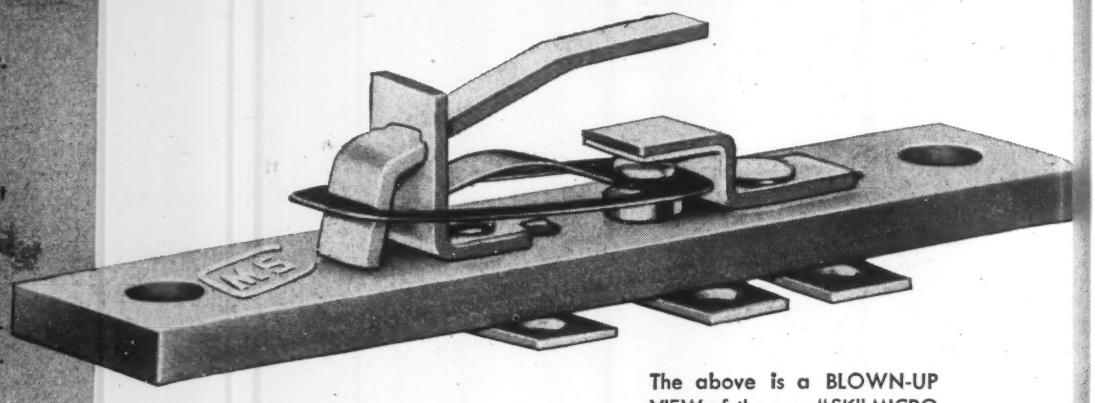
**MOVEMENT DIFFERENTIAL**
.008"—.022".

**OVERTRAVEL**
1/32 Min. (1/16 Nominal).

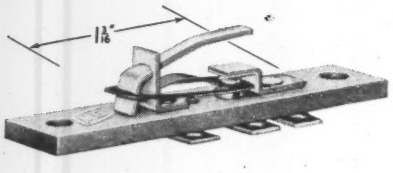
**FREE POSITION**
.343 Approximate.

**OPERATING POSITION**
.300 Approximate.

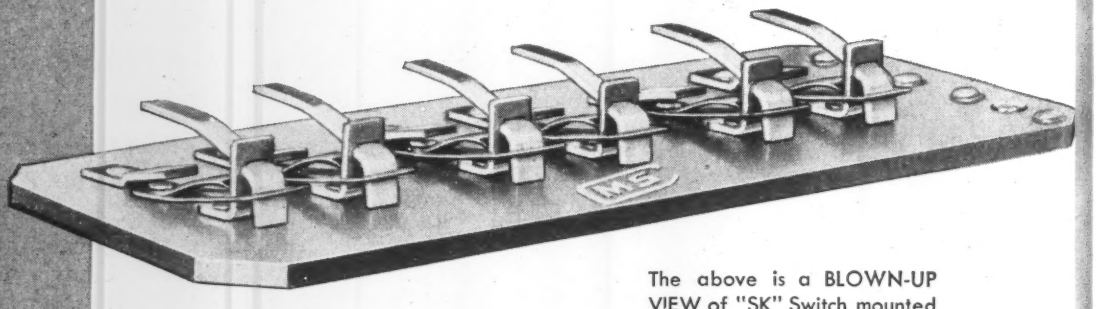
**MISCELLANEOUS**
Accurate repeatability—long life—resistance to vibration and impact.



The above is a BLOWN-UP VIEW of the new "SK" MICRO Precision Switch.




ACTUAL SIZE



The above is a BLOWN-UP VIEW of "SK" Switch mounted in gangs.

## THE "SK" CAN BE MOUNTED IN GANGS

This new compact light weight switch can be mounted in gangs with busses to provide many combinations of series, parallel, and individual switch connections. However, this is not standard construction but is available as a special construction on quantity orders. Made with the same careful workmanship that has characterized the MICRO Switch line, you'll find the "SK" dependable and long lived. The switch unit is only 1 3/16 inches long and when ganged lends itself to a wide variety of usages.

**MADE WITH THE "*KNOW-HOW*" BEHIND MILLIONS OF PRECISION SWITCHES**

# *Switch* Features Low Cost...
# ...Long Life...Dependability

The "Know-How" behind the manufacture of millions of MICRO Precision Switches is behind the development and manufacture of the new MICRO "SK" Switch. Engineered with mechanical exactness and manufactured with care from quality materials, one can expect the well known "MICRO" top performance from this new switch.

Small in size, light weight, unhoused with actuation adaptable for rotating or sliding cams or hand operated, it offers a new switching opportunity for design engineers.

The "SK" is available normally open, normally closed and double throw. It is available as a single unit or mounted in gangs with busses to provide many combinations of series, parallel, and individual switch connections. It features accurate repeatability, long life, high electrical capacity with resistance to vibration and impact.

The addition of the "SK" Switch to the "MICRO" line adds one more selection to a wide and complete line of switches. The MICRO Precision Switch line provides a completeness that makes it possible to select the exact switch to meet any specific electrical switch problem. The line offers a variety of sizes and shapes, electrical characteristics, and actuators.

The wide range experience of "MICRO" engineers in aiding with thousands of electrical switching problems and the "Know-How" gained in manufacturing millions of precision switches make them ideally qualified to aid you with your switching problems. Feel free to ask for their suggestions and help.

## MICRO *Precision* "LN-2" Limit Switch Equipped with Roller Arm Actuator for Limits . . . Safeties, Interlocks and Machine Control

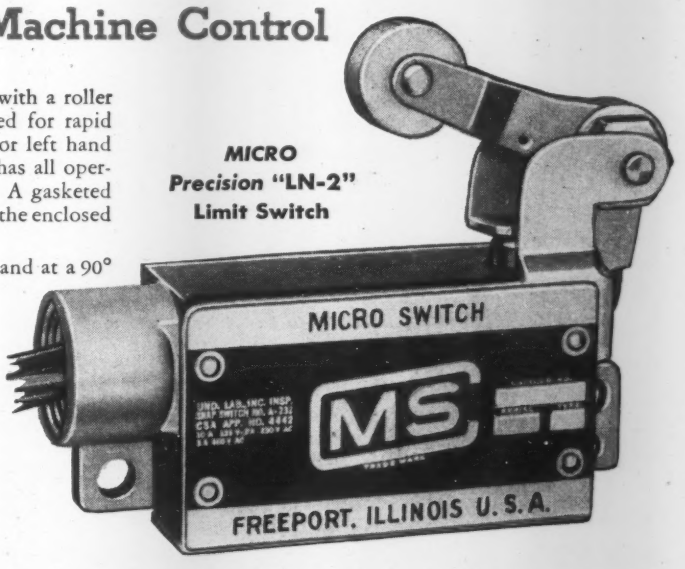
The type "LN-2" Limit Switch has a die cast housing with a roller arm actuator, adjustable through 225 degrees, designed for rapid cam or slide actuation. It is supplied for either right or left hand mounting. The "LN-2" is not immersion proof but it has all operating mechanisms and leads in conduit opening sealed. A gasketed cover prevents condensation, dust and dirt from reaching the enclosed switching element.

The following characteristics are measured at the roller and at a 90° angle with the lever.

| | |
|---|---|
| Operating Force | 3 lb., max. |
| Release Force | ¼ lb., min. |
| Pretravel | 3° max., (5/64 in., max.) |
| Overtravel | 17° max., (15/32 in., min.) |
| Movement Differential | ½° min., (0.014 in., max.) |
| Net Weight | 0.087 lbs., max. |

For further information or suggestions on the use of the "LN-2" MICRO Precision Switch, contact the nearest MICRO Branch or Sales Representative listed below.

**THIS SWITCH AVAILABLE SOON!**




***MICRO Precision* "LN-2" Limit Switch**

# MICRO *Precision Switches*

© 1947, First Industrial Corp.

**BRANCH OFFICES**

CHICAGO 6.....308 W. Washington St.
NEW YORK 17.....101 Park Avenue
CLEVELAND 3.....4900 Euclid Avenue
LOS ANGELES 14.....1709 West 8th St.
BOSTON 16.....126 Newbury Street

MICRO SWITCH
A DIVISION OF FIRST INDUSTRIAL CORPORATION
FREEPORT, ILLINOIS, U.S.A.

**SALES REPRESENTATIVES**

PORTLAND, ORE.....917 S. W. Oak Street
DALLAS 4.....2502 McKinney Ave.
ST. LOUIS 3.....1218 Olive Street
TORONTO, Ontario, Can.....11 King St.

*Here, your Spring gets*

*-Point Production Analysis*

for SIZE OF ORDER

for UNIFORMITY (if repeat order)

for PROPER TOOLING

for SPECIALIZED MACHINERY

*. . . Springs made by Wallace Barnes are job-engineered—appraised for those specifications which, if not properly anticipated, may result in extra operations which naturally means extra cost. By use of specialized departments, ingenious machines and toolmakers with experience and imagination, operations are reduced to a minimum consistent with quality and quantity desired. Wallace Barnes job-engineering, working simultaneously with your design-engineering, should result in the greatest production economy and the best spring for your purpose.*

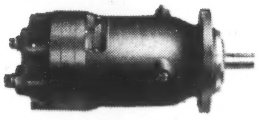
Wallace Barnes SPRINGS

SMALL STAMPINGS • WIRE FORMS • HAIRSPRINGS • COLD ROLLED SPRING STEEL

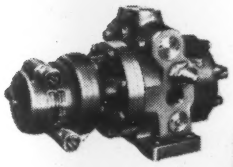
WALLACE BARNES COMPANY
BRISTOL, CONN.

DIVISION OF THE ASSOCIATED SPRING CORP.

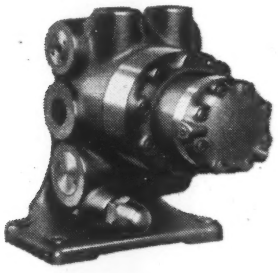
AND IN CANADA, THE WALLACE BARNES CO., LTD., HAMILTON, ONTARIO



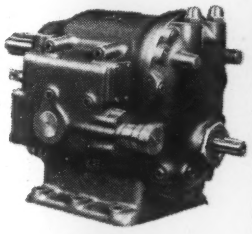
FLUID MOTORS



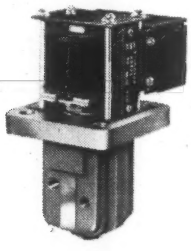
PUMPS



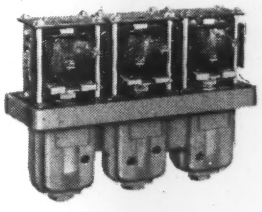
CLAMPING PUMPS



TRANSMISSIONS

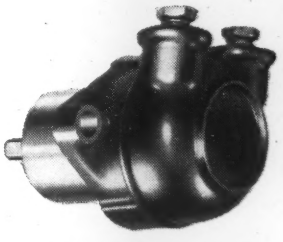


SINGLE SOLENOID VALVES



TRIPLE SOLENOID VALVES

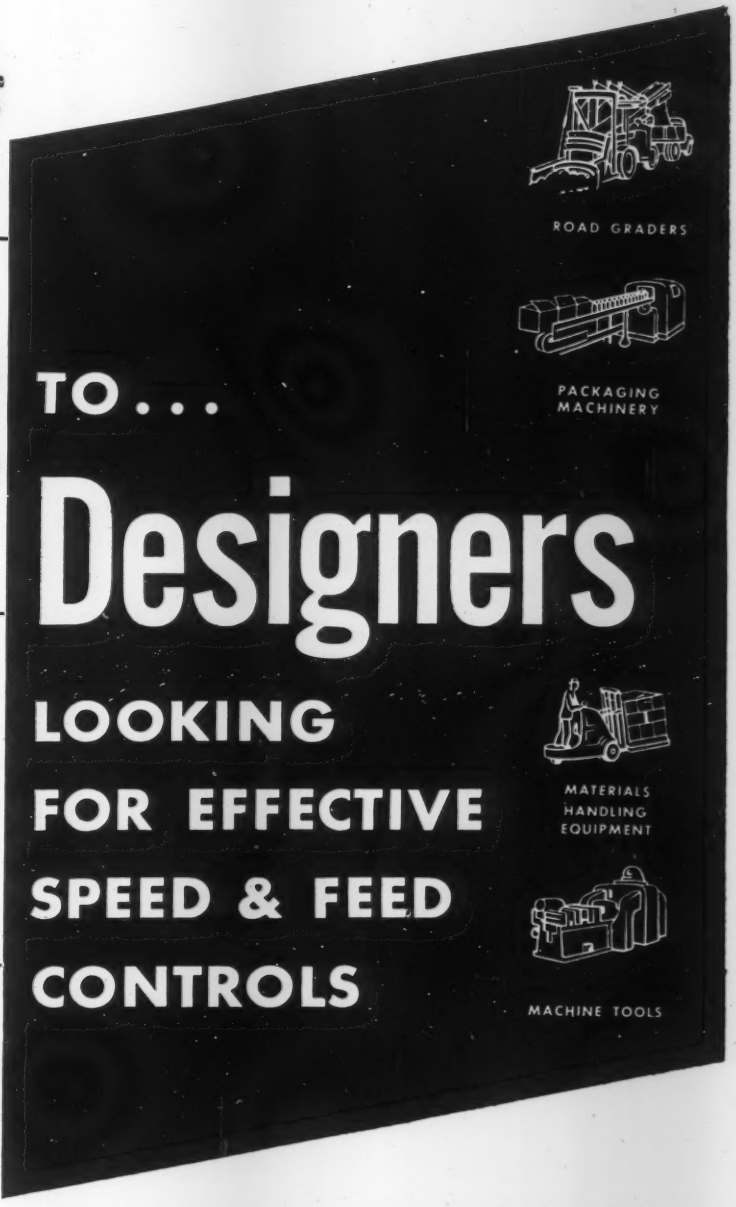
FOUR-WAY VALVES



LUBRICATING PUMPS

## FREE DATA

is included in this series of up-to-date bulletins. Write for your copies today. Ask for bulletins No. M-15




Here's your answer to hydraulic equipment design problems. In proper combinations, these time-tested and perfected hydraulic elements produce smooth and effective speed and feed controls. Proper combinations and circuits are arrived at through design conferences between you and our hydraulic application engineers.

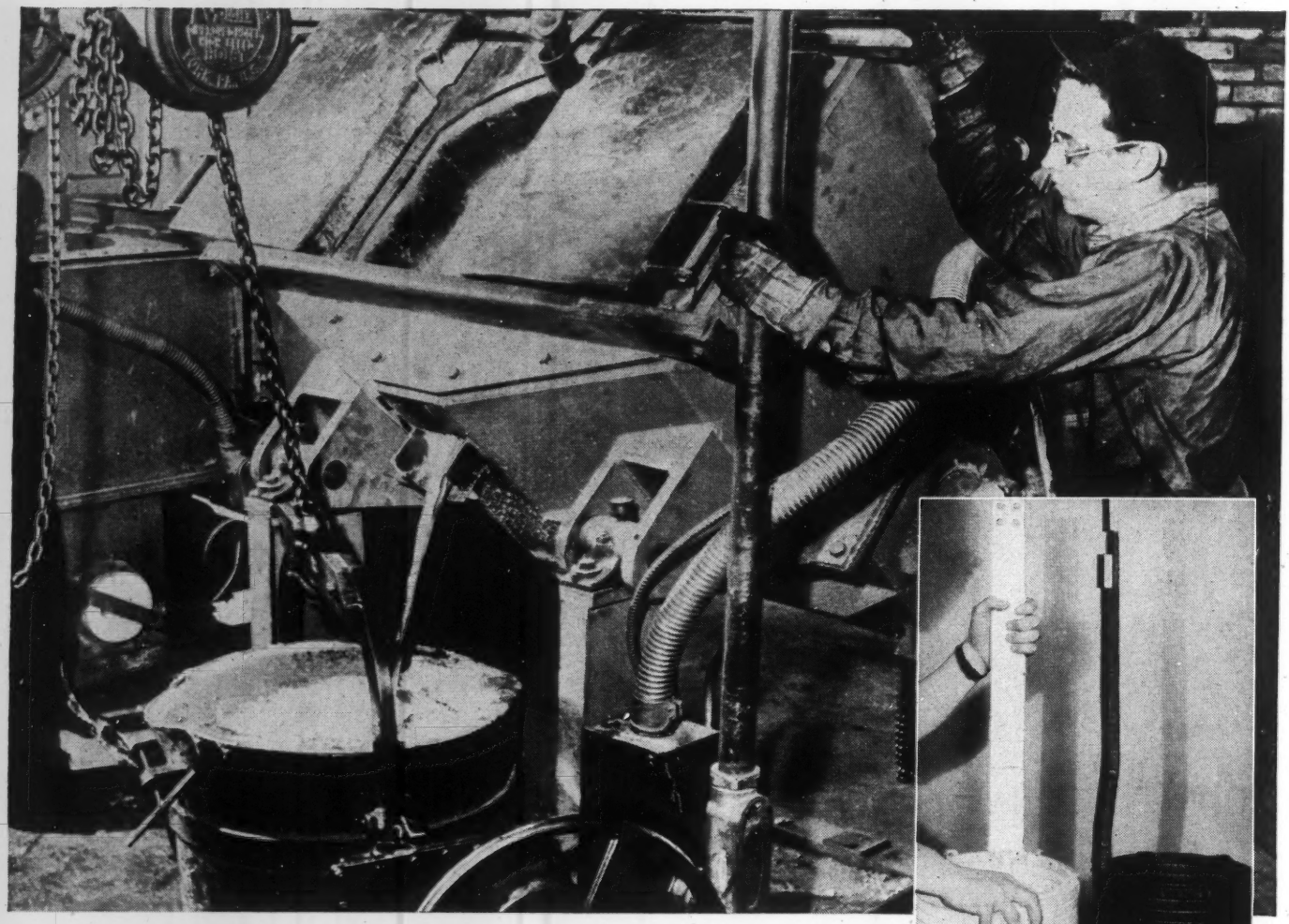
When designing new equipment or re-designing present models, call in a Sundstrand hydraulic application engineer. He will suggest the best combination of these hydraulic elements to meet your design requirements. There is no obligation for this service.

SUNDSTRAND MACHINE TOOL CO. · ROCKFORD, ILLINOIS U.S.A.

**SUNDSTRAND PUMP DIVISION**

2559 ELEVENTH STREET • ROCKFORD, ILLINOIS

FUEL UNITS • HYDRAULIC PUMPS • TRANSMISSIONS • FLUID MOTORS • VALVES and CONTROLS



# WHY FIBERGLAS TAPE IS USED ON *Induction Furnace Coils*

In metal-melting furnaces, high temperatures create tough insulation problems. For example, around the Fiberglas-insulated coils, in the furnaces made by the Ajax Engineering Corporation, Trenton, N. J., temperatures are in excess of 300° F. from radiation and conduction alone. And the internal heat from the coil itself boosts the operating temperature considerably higher.

Tape woven from Fiberglas yarns, is wrapped around the copper conductors, the coils are formed, then dip-impregnated with modified phenolic high-temperature insulating varnish.

This is typical of many applications in which Fiberglas, in various forms, is being used to provide a margin of safety in electrical equipment. For Fiberglas withstands heat far beyond the temperature range of even the newer insulating varnishes. Moreover, should the impregnants burn out, the Fiberglas base still provides protection as a permanent spacer.

Fiberglas Electrical Insulating Materials are available in forms to meet practically every insulation need. If you are concerned with the design, manufacture, use or maintenance of electrical equipment, get all the facts about Fiberglas Electrical Insulations. Write for catalog EL46-11—Owens-Corning Fiberglas Corporation, Department 808, Toledo 1, Ohio. Branches in principal cities.

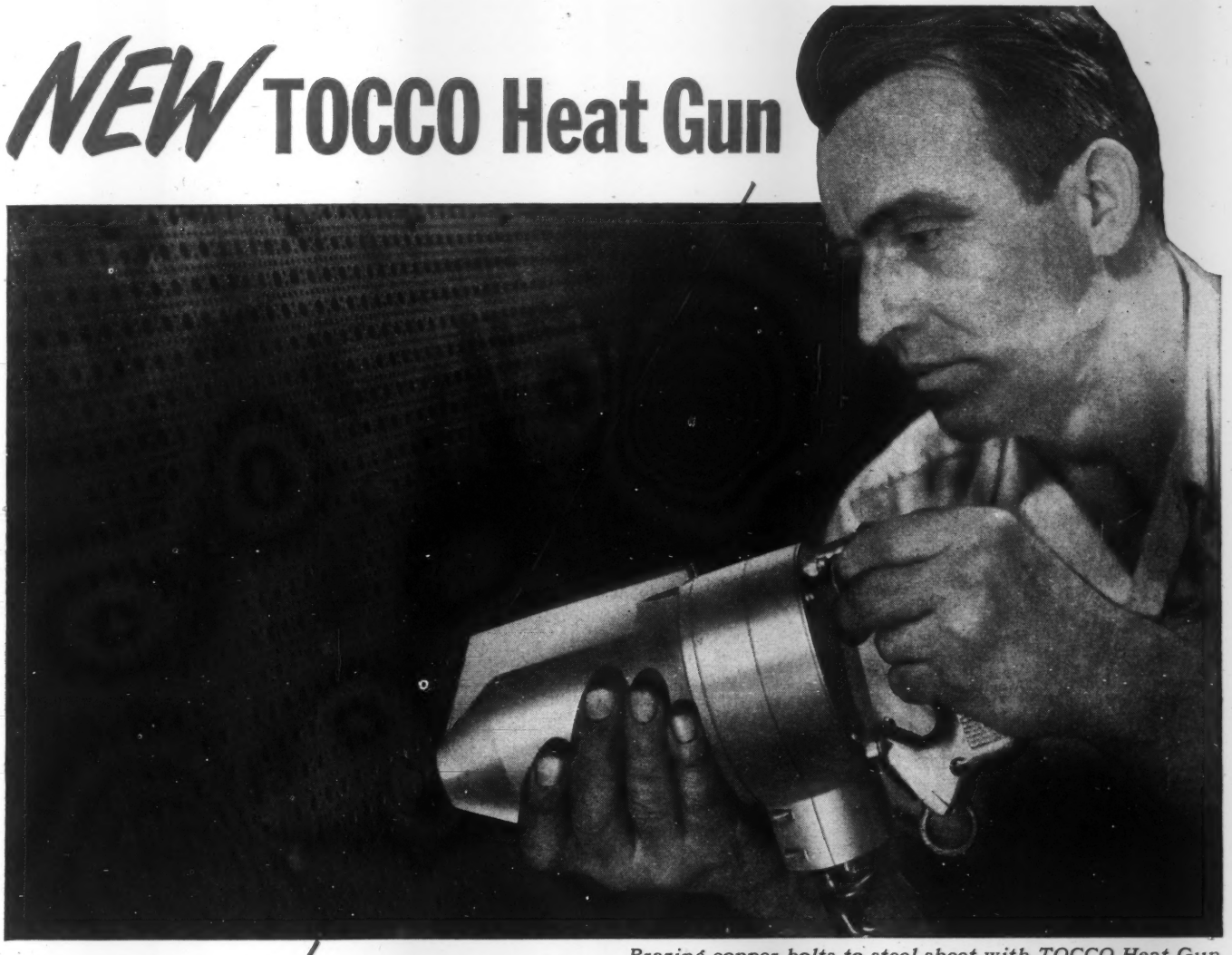
*In Canada: Fiberglas Canada Ltd., Toronto, Ontario.*

OWENS-CORNING
FIBERGLAS
Tm. REG. U.S. PAT. OFF.

ELECTRICAL INSULATING MATERIALS

TAPES • CLOTHS • BRAIDED SLEEVING • VARNISHED TUBING • MICA COMBINATIONS • LAMINATES

# *NEW* TOCCO Heat Gun



*Brazing copper bolts to steel sheet with TOCCO Heat Gun*

## increases versatility of induction heating

NOW you can bring speedy, low-cost, localized induction heat to the work instead of bringing the work to the heat.

The revolutionary new TOCCO Heat Gun . . . a portable inductor with trigger heat control . . . increases the versatility and flexibility of induction heating. It can be used for soldering, hardening, brazing, annealing, melting and forging. The gun is applicable to both ferrous and non-ferrous metal parts. It is especially valuable for (1) small runs of diversified parts where it often eliminates the need for special inductor coils, and (2) for large or complex parts or assemblies too bulky for easy positioning in a stationary inductor coil.

Mail the coupon for complete details.

**THE OHIO CRANKSHAFT COMPANY**

**FREE BULLETIN**

**TOCCO**

**Mail Coupon Today**

THE OHIO CRANKSHAFT CO.
Dept. B-1, Cleveland 1, Ohio

Send details on New TOCCO Heat Gun.

Name.....

Company.....

Address.....

City.....Zone... State...

# For Superior Performance...

# DESIGN

## with ACADIA Synthetic Rubber

**SHEETS • EXTRUSIONS**
**CUT AND MOLDED PARTS**

Component parts processed from Acadia Synthetics excel in many characteristics—including plasticity, elasticity, resilience, etc.—plus greater resistance to light, air, heat, wear, oil and age. Possible applications are almost unlimited. Acadia Synthetic Rubbers cut, mold and extrude to very close tolerances—in any shape, size or type.

In checking specifications, you may find that the original part, re-designed in an Acadia Synthetic, gives superior performance, greater dependability and longer service—*very often at lower cost.* Whatever your requirements may be . . . Acadia's engineers will gladly help you select the right synthetic rubber and adapt it to your product. *Write today.*

DIVISION OF WESTERN FELT WORKS

**ACADIA** *Synthetic* **PRODUCTS**

Processors of Synthetic Rubber and Plastics • Sheets • Extrusions Molded Parts

DIVISION WESTERN FELT WORKS

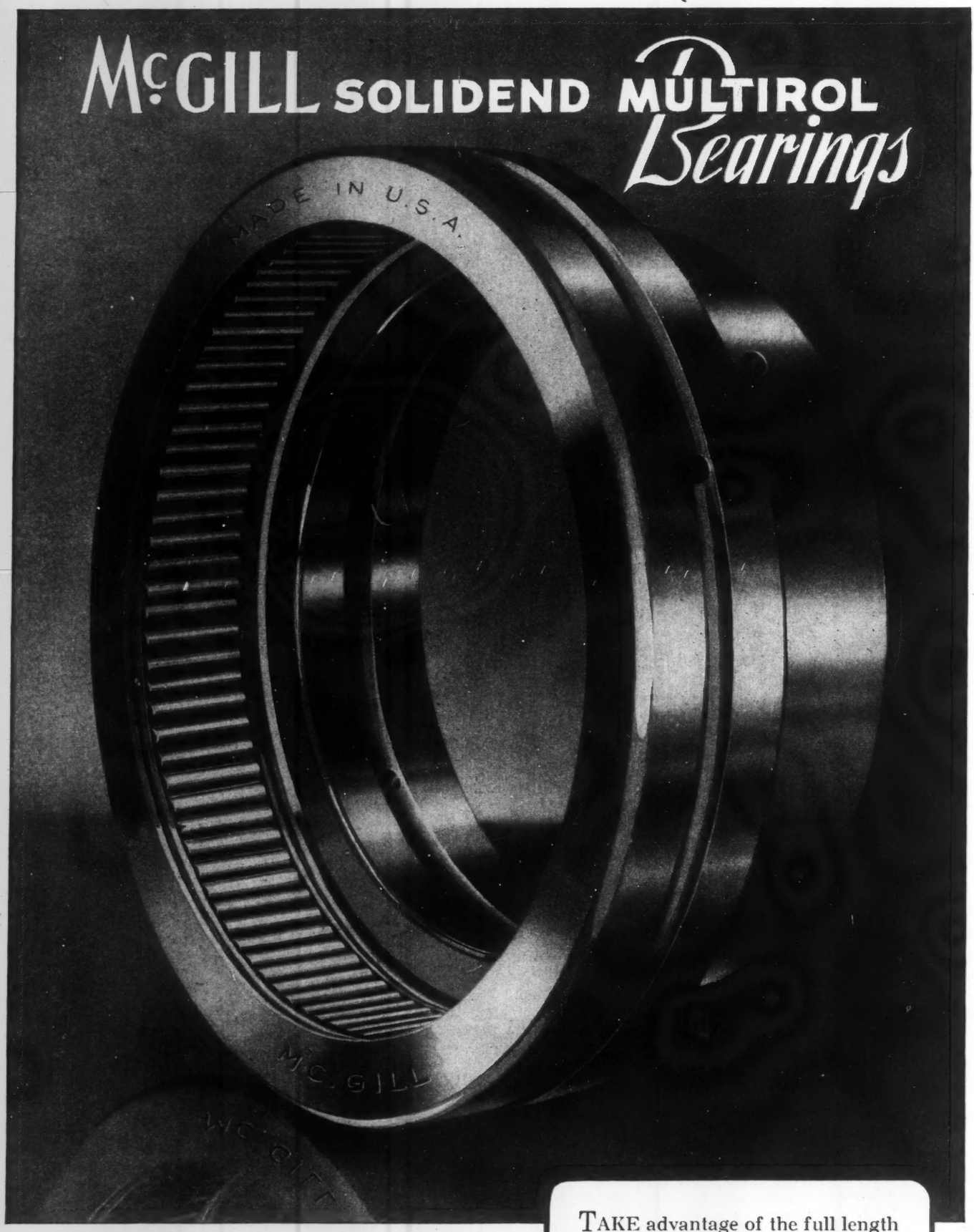
*Branch Offices in All Principal Cities*

Largest Independent Manufacturers and Cutters of Felt

4035-4117 Ogden Avenue, Chicago 23, Illinois

The heart of any machine is its motor
Use B-LINE the Lifetime Motor
DEPENDABILITY
LONG LIFE
B
LINE
ECONOMY
THE BROWN-BROCKMEYER COMPANY
LEADING INDEPENDENT MOTOR MANUFACTURER
1030-1044 SMITHVILLE ROAD
DAYTON 1, OHIO
PLANTS AT DAYTON, WILMINGTON AND XENIA, OHIO—OFFICES IN PRINCIPAL CITIES

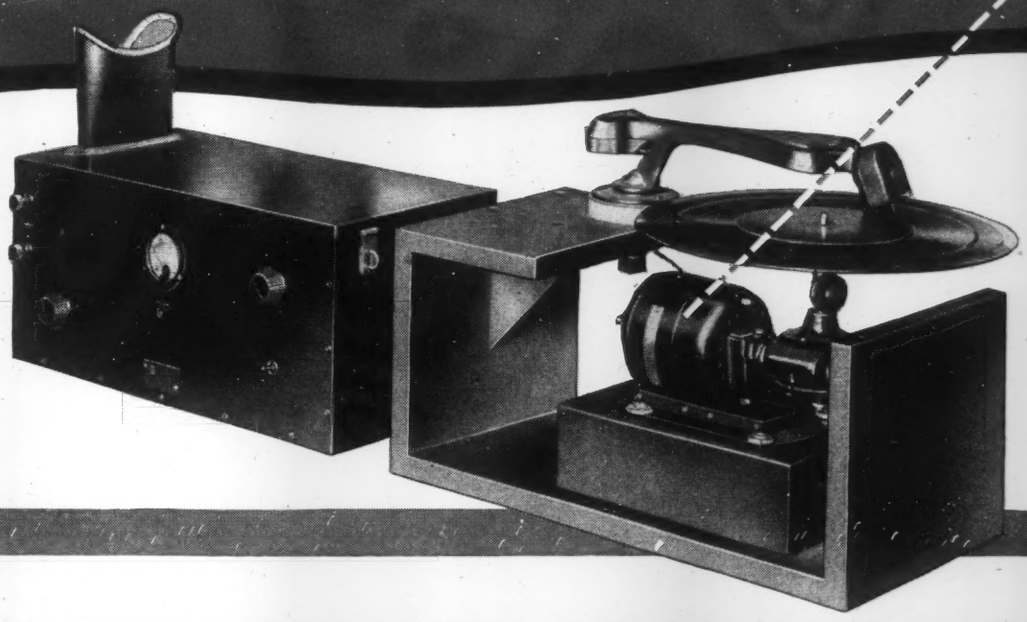
# McGILL SOLIDEND MULTIROL Bearings




TAKE advantage of the full length rollers of McGILL "Solidend" *MULTIROL* Bearings. We will be glad to send you our catalog SM-42.

McGILL MANUFACTURING COMPANY, INC.
*Manufacturers of Ball and Roller Bearings*
VALPARAISO, INDIANA

# From R.P.M.···to a Bead of Light



## THIS WOW MACHINE MEASURES SPEED VARIATION IN INCHES ...OK'S R&M GEAR-HEAD MOTORS FOR R.C.A. TRANSCRIBERS

● Guesswork goes *out of the window* when it comes to R & M turntable drives for R.C.A. transcription machines. Even the use of a synchronous motor is not *positive* assurance that spindle speed will stay within permissible limits. It's *that* exacting.

### CHECK EVERY POINT

Minor imperfections in the gear train could cause instantaneous *surges*—produce changes in tone pitch especially noticeable during sustained notes. To prevent such possibility, tooth shapes of finished gears in the R & M drive are projected and greatly *enlarged* for comparison with accurate contours.

And, as a *double check,* assembled drives go into the WOW Machine for final performance inspection. Developed by R.C.A., the WOW Machine consists, in part, of a turntable with constant-tone record which is revolved by the drive being tested. Vibrations picked up by the tone arm are transformed into a pulsating *bead of light,* visible through the eye piece.

### DRIVES MUST BE RIGHT

Calibrations enable the operator to read the length of this light bead. A one-half inch bead represents .6 of 1% spindle speed variation—the maximum allowable. Inspection is precise, quick, *sure.*

*Whatever* your powering problems, Robbins & Myers engineers are ready with the kind of cooperation in design and production that only *long experience* makes possible. Meeting unusual motor needs has been an R & M specialty for many years.

**ROBBINS & MYERS • INC.** MOTOR DIVISION · SPRINGFIELD, OHIO
In Canada: Robbins & Myers Co., of Canada, Ltd., Brantford, Ont.

MOTORS · HOISTS · CRANES · MACHINE DRIVES · FANS · MOYNO PUMPS · FOUNDED 1878

# 36 TECHNICAL PAGES
## on carbon brushes

LOTS of help for all electrical men who design, build, maintain or work with motors . . . in this new Speer book. In technical, non-commercial language it discusses:

**BRUSH CHARACTERISTICS**—(specific resistance, contact drop, coefficient of friction, hardness.) • **BRUSH GRADES** • **SERVICE RECOMMENDATIONS** • **BRUSH STANDARDS** • **DEFINITIONS** • **SHUNT LOCATION DATA** • **INSTALLATION HINTS**—(proper fit and connections; pressure; staggering; brush angle.) • **HOW TO SPECIFY BRUSHES**

***PLUS*** . . . Brush data forms. List data for *your* machines; Speer recommends the proper brush.

***PLUS*** . . . additional pages of text and pictures on graphite anodes for electronic tubes; carbon contacts; carbon welding products; packing rings, etc.

**SPEER WILL KEEP YOUR COPY UP TO DATE**

When you request your copy of "Carbon Products," Speer records your name and address. Additions and changes are sent you promptly as they occur. But you must ask for your copy first . . . *there will be no unrequested mailings.* Write Speer *now.*

Speer
CARBON COMPANY
ST. MARYS, PENNA.

brushes • contacts • welding electrodes • graphite anodes • rheostat discs • packing rings • carbon parts

CHICAGO • CLEVELAND • DETROIT • MILWAUKEE • NEW YORK • PITTSBURGH

2307 A

# SMOOTH POWER

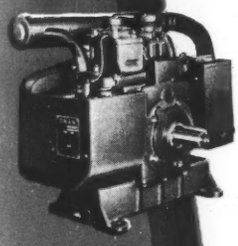
## *Two-Cylinder*

## THE NEW ONAN

*AIR-COOLED*

## "CK" ENGINE

## 10 H.P. 4-CYCLE



**Two-cylinder horizontal opposed design gives the new, heavy-duty CK engine unusual running smoothness. Short, rigid crankshaft . . . 2-inch diameter main and 1⅝-inch diameter rod bearings . . . pressure lubrication . . . axial-flow cooling fan . . . aluminum construction giving 4-to-1 cooling advantage over cast iron . . . weighs only 97 pounds and fits neatly into 15" x 19" x 18" space. Designed to solve engine power problems in industry, agriculture and other fields. Proven by thousands in use today . . . now in mass production . . . prompt delivery.**

**Also has: Built-in precision governor . . . downdraft concentric carburetor for wide-angle operation . . . oil bath air cleaner . . . fuel pump . . . oil pressure gauge . . . crankcase fumes exhausted to carburetor . . . hermetically sealed magneto ignition coil with easy-to-get-at breaker points.**

*Electric Starting*

Built-in electric push-button or automatic starting is optional; adds little to overall dimensions

**WRITE FOR** Illustrated, complete specifications

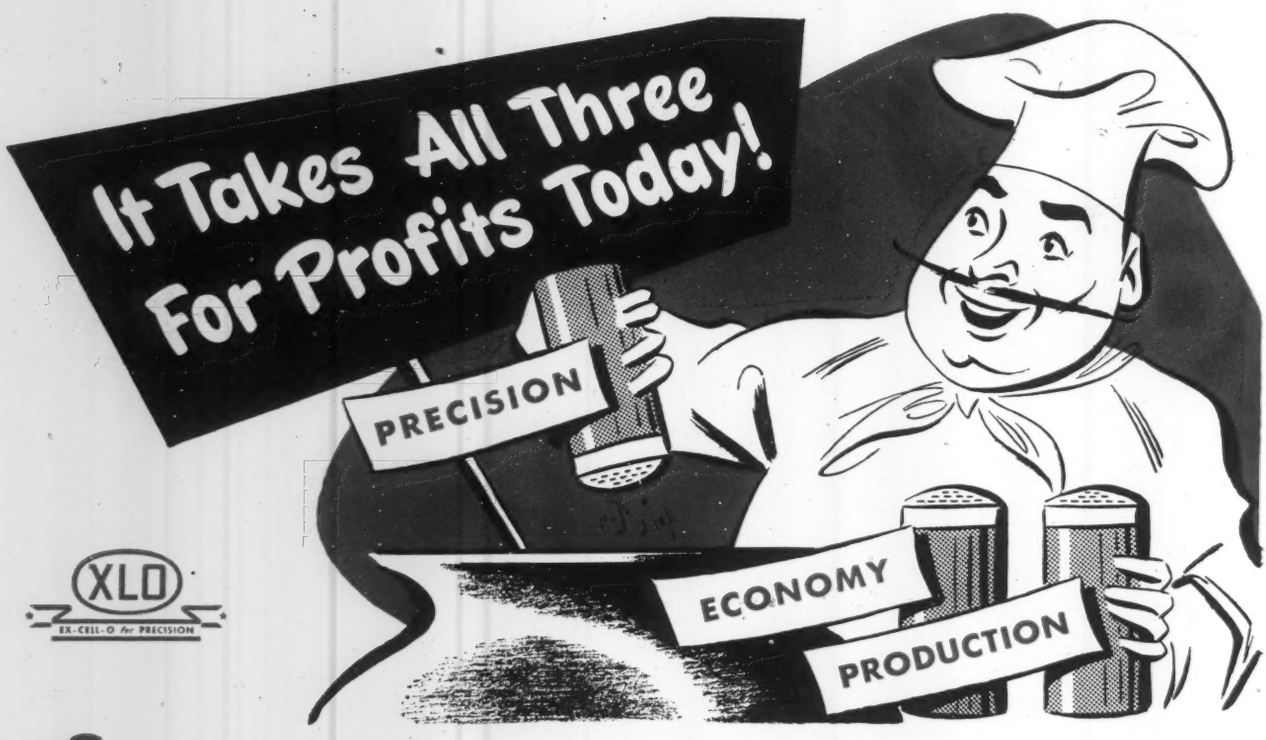
ONAN ELECTRIC PLANTS—A.C.—350 to 35,000 watts in standard voltages and frequencies; D.C.—600 to 10,000 watts, 115 and 230 volts. Battery chargers—500 to 3,500 watts, 6 to 115 volts.

ONAN AIR-COOLED ENGINES—CK: 2-cylinder opposed, 10 h.p.; BH: 2-cylinder opposed, 5.5 h.p.; 1B: 1-cylinder, 2.5 h.p.

**D. W. ONAN and SONS INC.**
**4334 Royalston Ave. Minneapolis 5, Minn.**

ONAN PRODUCTS

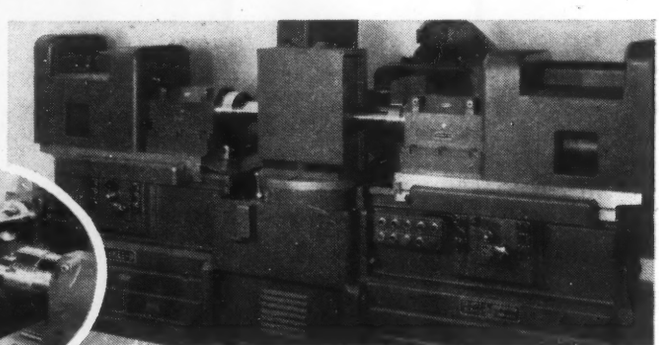
# ONAN *4-Cycle* ENGINES




**Special-purpose machines built from standard sections . . . for higher production, improved accuracy, lower unit cost.**

The Ex-Cell-O Way-Type Precision Boring Machine has three features that make it a good investment today: *Efficiency* . . . the machine is designed to perform definite operations on a specific part with accuracy and speed. The whole arrangement of machine and fixture is planned for efficient boring and handling of this one part. *Low First Cost* . . . each Ex-Cell-O Way Machine consists of one or more *standard wing units* combined with a fixture unit. The use of standard units in special machine design keeps costs down. *Re-Use* . . . being composed of standard self-contained units, Ex-Cell-O Way Machines can be rearranged as production requirements necessitate. The individual units can be arranged in different combinations and the original cost of the machine spread over many years of production. Further information on Ex-Cell-O Precision Way Machines and application pictures are available in the form of a booklet. Send for a copy today to Ex-Cell-O Corporation, 1200 Oakman Boulevard, Detroit 6, Michigan . . . ask for Ex-Cell-O Bulletin 31631.

*To Right:* Ex-Cell-O Three-Way Precision Boring Machine. Close-up view from rear shows typical job. Four holes are finish bored, all held in specified relation, and one boss is faced, all with only one handling of the part. The spindle at the left and the one in the background at the right bore the differential holes in line. The spindle in the right foreground finishes the pinion bore and the pinion flange bore in line and faces the pinion flange. The facing tool is carried in a facing head that feeds out after the boring operation is complete. The fixture is mounted on a rotary table which is turned manually for loading and unloading the work from the front of the machine.

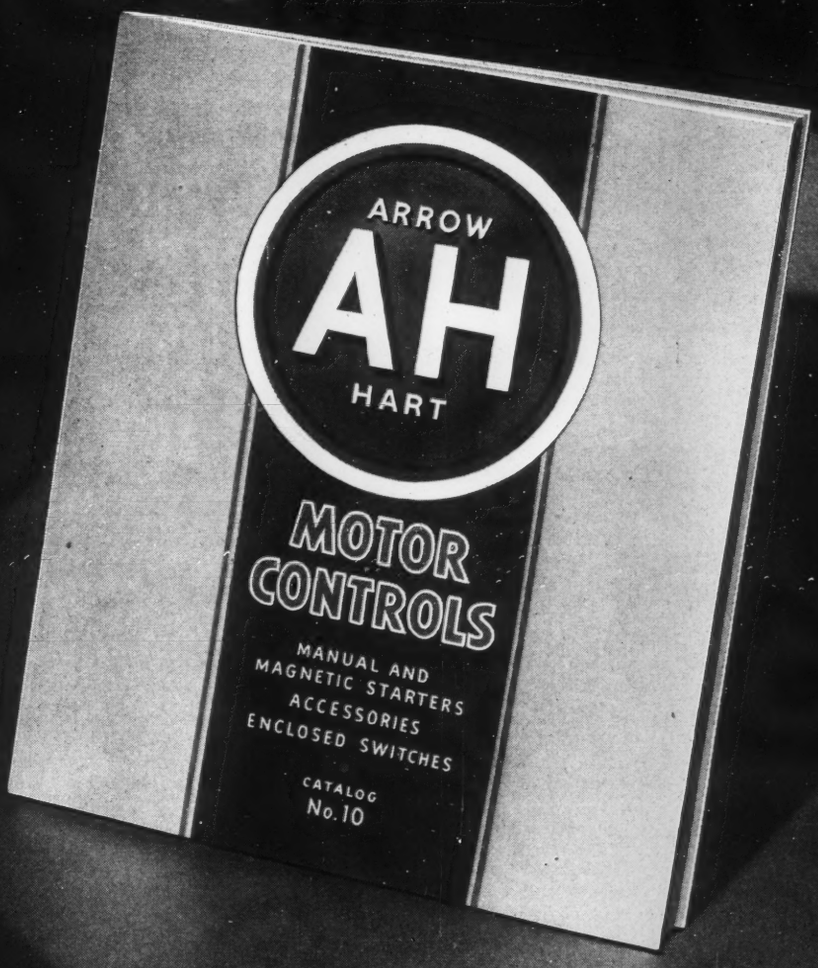


47—5

**EX-CELL-O CORPORATION** DETROIT 6 MICHIGAN

MANUFACTURERS OF PRECISION MACHINE TOOLS • CONTINENTAL CUTTING TOOLS • MISCELLANEOUS PRODUCTION PARTS • FUEL INJECTION EQUIPMENT • RAILROAD PINS AND BUSHINGS • DRILL JIG BUSHINGS • PURE-PAK PAPER MILK BOTTLE MACHINES

# New Motor Controls Catalog




## *Send* this Coupon

for your up-to-date listings of Motor Controls, — Manual and Magnetic Starters, Push Button Stations and Enclosed Switches, — including basic *new principle* Magnetic Controls, just out!

*To* Industrial Control Division, Arrow-Hart & Hegeman Electric Company, Hartford 6, Conn.

*Send* your new 124-page MOTOR CONTROLS Catalog No. 10 to

(*Name*)_____

(*Company*)_____

(*Address*)_____

(*City & State*)_____

INDUSTRIAL CONTROL DIVISION

**THE ARROW-HART & HEGEMAN ELECTRIC COMPANY, HARTFORD, CONN., U. S. A.**

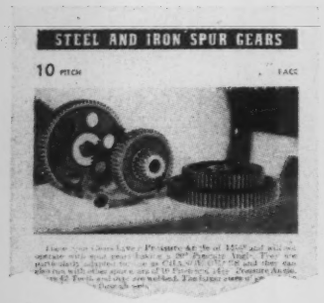
# ORDER from "Cover to Cover"

# 320 PAGES

## OF POWER TRANSMISSION EQUIPMENT AND COMPONENT MACHINE PARTS

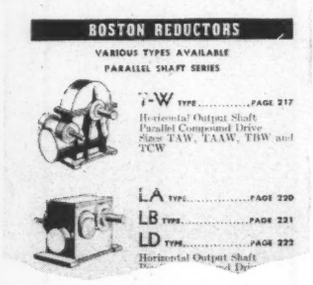
***The complete "BOSTON" line . . .***

## SELECT FROM THESE 4 MAIN GROUPS!




**1 GEARS** 107 Pages devoted to stock sizes of Brass, Steel, Iron, Non-metallic and Fabroil gears. Spur gears, Miter & Bevel gears, Worms & Worm gears, Internal gears, Helical gears, Change gears, Rack, Pinion Wire and Stem Spur Gear Pinions.

**2 CHAIN & SPROCKETS** Here's 37 Pages full of Bronze, Steel and Iron sprockets for Roller chain, Ladder chain, Stud chain and Block chain. Also, Attachment Roller chain and Non-corrosive Roller chain. Plus Chain Drive Selection Chart and other pertinent data.



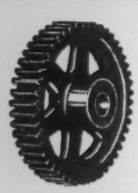

**3 SPEED REDUCERS** 87 Pages of stock ratios of speed reduction units, motorized (Ratiomotors) and un-motorized (Reductors). Selection charts, dimensions, Horizontal types, Vertical types, Compound Reduction types, Miter Gear Units, etc.

**4 MISC. PRODUCTS** To "complete" the BOSTON line, 64 Pages are divided into various groups of Component Machine Parts — Set-screw Collars, Sleeve Couplings, Shaft Couplings, Universal Joints, Pillow Blocks & Shaft Supports, Ball Bearings, Bushings, Washers and Pulleys.

**CONSULT OUR CATALOG FOR COMPLETE DIMENSIONS AND SPECIFICATIONS.....order by catalog number**

## BOSTON GEAR WORKS, INC. NORTH QUINCY 71, MASSACHUSETTS

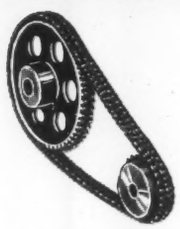
**THE COMPLETE LINE OF "BOSTON" PRODUCTS LISTED IN OUR**

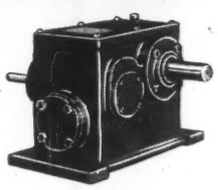

SPUR GEARS

INTERNAL GEARS

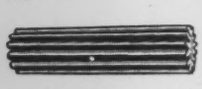
BEVEL GEARS

MITER GEARS


CHAIN & SPROCKETS

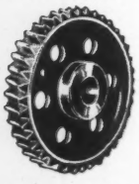

SPEED REDUCERS

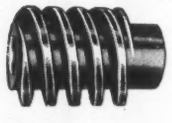
RACK


PINION WIRE

HELICAL GEARS

SPIRAL MITERS


WORM GEARS


WORMS

SPEED REDUCERS (Motorized)

# BUY from "Coast to Coast"

## GET COMPLETE SERVICE ON "BOSTON" PRODUCTS FROM THESE DISTRIBUTORS

(THEY CAN SHIP MANY "BOSTON" ITEMS FROM THEIR OWN LARGE STOCKS . . .)

AKRON, OHIO
Manufacturers Rubber & Supply Co.
380 South Broadway

ALBANY, NEW YORK
Sager-Spuck Supply Co.
364–366 Broadway

ALLENTOWN, PENNSYLVANIA
Wm. H. Taylor & Co., Inc.
250–256 Hamilton Street

ATLANTA, GEORGIA
J. M. Tull Metal & Supply Co., Inc.
285 Marietta Street

BALTIMORE, MARYLAND
Carey Machinery & Supply Co.
119–121 E. Lombard Street

BOSTON, MASSACHUSETTS
Chandler & Farquhar Co., Inc.
900 Commonwealth Avenue

BRIDGEPORT, CONNECTICUT
The Hawley Hardware Co.
1120 Main Street

BROOKLYN, NEW YORK
H. L. Dickie
314 — 36th Street

BUFFALO, NEW YORK
Root, Neal & Company
64 Peabody Street

CANTON, OHIO
Manufacturers Rubber & Supply Co.
707–711 — 12th St., N. E.

CHARLOTTE, NORTH CAROLINA
Matthews-Morse Sales Co.
909 South Mint Street

CHICAGO, ILLINOIS
Berry Bearing Company
2633–35 S. Michigan Avenue
Boston Gear Works, Inc.
955 W. Washington Blvd.
Chicago Pulley & Shafting Co.
23 N. Desplaines Street
Power Transmission Equipment Co.
640 W. Washington Blvd.

CLEVELAND, OHIO
Boston Gear Works, Inc.
211 St. Clair Ave., N. W.
Mau-Sherwood Supply Co.
800 Lime Road

CINCINNATI, OHIO
Queen City Supply Co.
Pearl & Elm Streets

DALLAS, TEXAS
Geo. J. Fix Company
2413–15 Commerce Street

DAVENPORT, IOWA
Standard Bearings Company
318 Ripley Street

DAYTON, OHIO
Klinger-Dills Company
116–120 North Jefferson St.

DENVER, COLORADO
Western Belting & Packing Co.
1720–28 Wazee Street

DES MOINES, IOWA
Standard Bearings Company
1014 Grand Avenue

DETROIT, MICHIGAN
Chas. A. Strelinger Co.
149–165 East Larned Street

EVANSVILLE, INDIANA
Bearings Service Co., Inc.
9 N. W. First Street

HARTFORD, CONNECTICUT
Silliter-Holden, inc.
433 New Park Avenue

INDIANAPOLIS, INDIANA
Indianapolis Belting & Supply Co.
30–36 So. Capitol Avenue
Vonnegut Hardware Company
120–124 E. Washington Street

JACKSONVILLE, FLORIDA
S. B. Hubbard Company
32 West Bay Street

KANSAS CITY, MISSOURI
Ellfeldt Mchy. & Supply Co.
1219 McGee Street

LOS ANGELES, CALIFORNIA
Andrews Hardware & Metal Co.
334 South Main Street
Garrett Supply Company
3844 South Santa Fe Avenue

LOUISVILLE, KENTUCKY
Industrial Equipment Company
1377 South Seventh Street

MEMPHIS, TENNESSEE
Lewis Supply Company
Main at Butler Streets

MIAMI, FLORIDA
General Equipment & Supply, Inc.
552–56 N. W. Fifth Street

MILWAUKEE, WISCONSIN
Western Iron Stores Co.
319 East Clybourn Street
Wisconsin Bearing Company
915 North Market Street

MINNEAPOLIS, MINNESOTA
R. C. Duncan Company
411 Washington Avenue, N.

MONTREAL, CANADA
Renold-Coventry, Ltd.
1006 Mountain Street

NEWARK, NEW JERSEY
Squier, Schilling & Skiff
419 Plane Street

NEW ORLEANS, LOUISIANA
R. J. Tricon Company
747 Tchoupitoulas Street

NEW YORK, N. Y.
L. C. Biglow & Co., Inc.
250 West 54th Street
Boston Gear Works, Inc.
151 Lafayette Street

NORTH QUINCY, MASSACHUSETTS
Boston Gear Works, Inc.
14 Hayward Street

OAKLAND, CALIFORNIA
C. W. Marwedel
11th & Alice Streets

PEORIA, ILLINOIS
Illinois Bearing Company
513 Franklin Street

PHILADELPHIA, PENNSYLVANIA
Boston Gear Works, Inc.
Terminal Commerce Bldg.,
401 No. Broad Street
Lindsay, Oberholzer & Co.
4432 Ridge Avenue
Maddock & Company
42 N. Sixth Street

PITTSBURGH, PENNSYLVANIA
Somers, Fitler & Todd Co.
313–327 Water Street

PORTLAND, OREGON
Woodbury & Company
133 S. W. 2nd Avenue

PROVIDENCE, RHODE ISLAND
Machine Parts Corporation
271 Washington Street

RICHMOND, VIRGINIA
Apex Machine Mfg. Company
216 S. Fifth Street

ROCHESTER, NEW YORK
John M. Forster Company
110 Mill Street

ST. LOUIS, MISSOURI
Colcord-Wright Mchy. & Supply Co.
1223–1229 North Broadway

ST. PAUL, MINNESOTA
R. C. Duncan Company
173 W. 4th Street

SAN FRANCISCO, CALIFORNIA
C. W. Marwedel
1235 Mission Street

SEATTLE, WASHINGTON
Cragin & Company
932 First Avenue South

SIOUX CITY, IOWA
Standard Bearings Company
127 — 6th Street

SOUTH BEND, INDIANA
Bearings Service Co., Inc.
216-A S. St. Joseph Street

SPRINGFIELD, MASSACHUSETTS
Boston Gear Works, Inc.
Myrick Building, 29 Worthington St.

SYRACUSE, NEW YORK
Syracuse Supply Company
314 West Fayette Street

TAMPA, FLORIDA
Southern Pump & Supply Co.
902 Twiggs St.

TOLEDO, OHIO
Ohio Belting & Transmission Co.
406 Orange Street

TORONTO, CANADA
Renold-Coventry, Ltd.
50 Edward Street

TRENTON, NEW JERSEY
Wiley-Hughes Supply Co.
801 New York Avenue

VANCOUVER, CANADA
Renold-Coventry, Ltd.
655 Davie Street

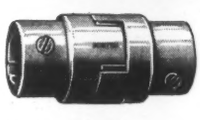
WATERBURY, CONNECTICUT
White Supply Company
477 West Main Street

WILKES-BARRE, PENNSYLVANIA
Holmes Metallic Company
519–521 So. Main Street

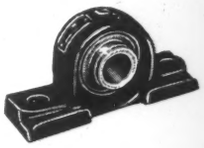
WINSTON-SALEM, N. C.
Kester Machinery Company
430 North Main Street

WORCESTER, MASSACHUSETTS
W. M. Steele Company
171 Fremont Street

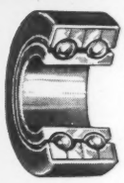
## GENERAL CATALOG NUMBER 54



COUPLINGS



PILLOW BLOCKS

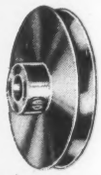


BALL BEARINGS

UNIVERSAL JOINTS

SHAFT SUPPORTS

COLLARS



PULLEYS

**FOR YOUR COPY OF CATALOG 54 USE THIS COUPON AND MAIL TO YOUR NEAREST "BOSTON" DISTRIBUTOR**

Please send me . . . . . copies of the new Boston Gear general catalog No. 54.

Name_____

Company_____

Street_____

City_____ Zone_____ State_____

# LINEAR "O" RINGS*

## *Effectively Seal*

## in many applications of which these 5 are typical

This composite drawing of a hydraulic cylinder illustrates the versatility of Linear "O" Rings. They can be used as static seals, gaskets or conventional "O" Ring packings.

Linear "O" Rings eliminate complicated, bulky assemblies. One "O" Ring effectively seals in either direction; requires no adjustment or mechanical pressure to maintain an effective seal; provides savings in manufacturing and assembly costs through design simplification; and can be installed by inexperienced hands.

These moulded synthetic rubber seals are available in high quality general purpose rubber compounds adaptable to a wide range of temperatures, pressures and fluids, or in a number of special compounds to meet unusual service conditions. Standard sizes range from ⅛" to 15½" I.D. and special sizes can be made as required.

Write for detailed information, today.

* Covered by Christensen United States Patent No. 2,180,795; all "O" Rings sold by Linear are manufactured under royalty agreement with patentee.

**Our more than 40 years' experience in the design and application of mechanical packings is at your service to help you solve your hydraulic design problems.**

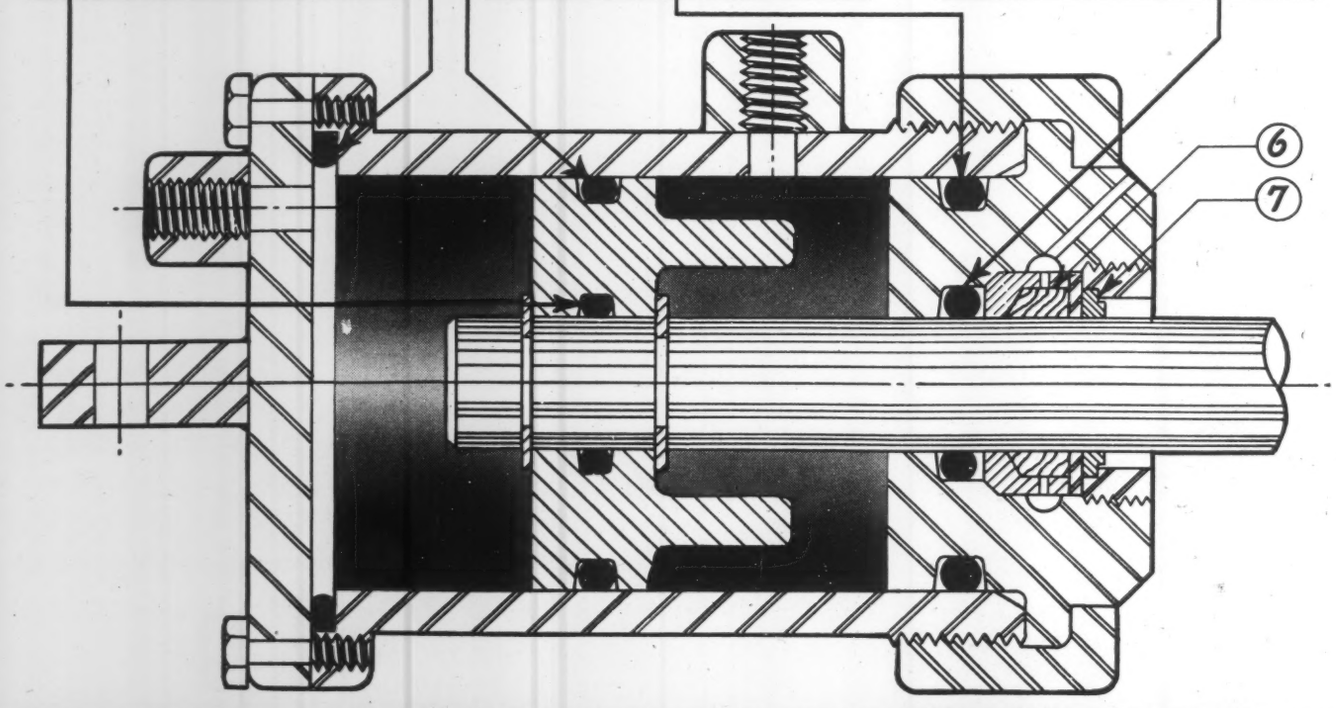
**FLANGE-TYPE STATIC SEAL APPLICATION**

**CONVENTIONAL "O" RING PISTON PACKING**

**PISTON ROD SEAL.** Installed in conjunction with felt lubricator washer (6) and bronze piston rod scraper ring (7). Lubricating washer should be employed in air-actuated equipment or where adequate lubrication is not supplied from pressure medium. Scraper ring is recommended where accumulations of caked mud, dirt, or ice are likely to adhere to piston rod.

**"O" RING STATIC SEAL FOR PISTON.** Permits the use of a straight piston rod and snap ring retention of piston.

**CYLINDER END CAP STATIC SEAL.** Could also be installed on external diameter of cylinder barrel.




LINEAR

**LINEAR** INCORPORATED

**OVER FORTY YEARS PACKING EXPERIENCE**

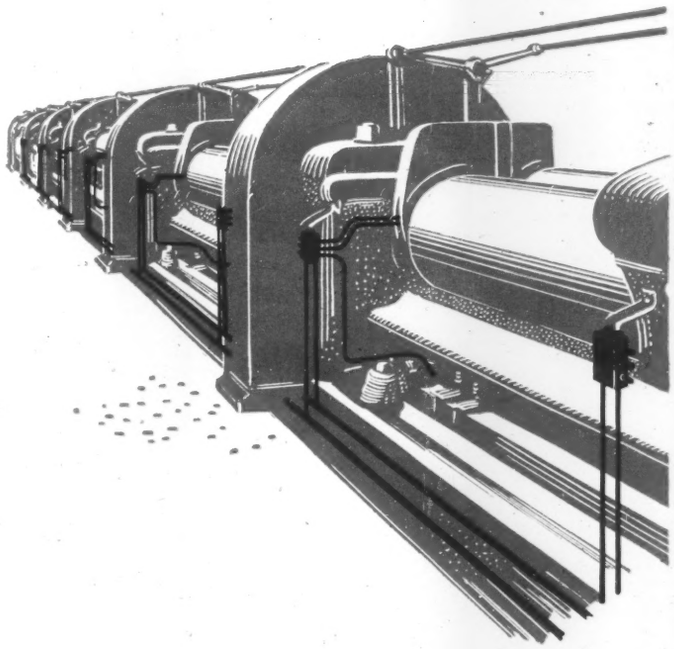
*Executive Offices and Factory*

**STATE ROAD and LEVICK STREET—PHILADELPHIA 35, PENNA.**

# Savings of $1910 a month

## from $7500 invested in Farval

**FARVAL**—*Studies in Centralized Lubrication No. 83*



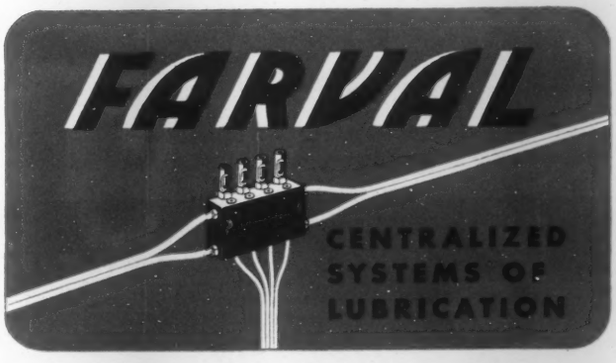
FOR 12 years, one of the large rubber companies has been enjoying the satisfaction and economy of Farval centralized lubrication on its 46 rubber mills. Formerly, bearings were lubricated with heavy cylinder oil through sight-feed cups. This work, done by hand, took eight oilers and cost $1400 a month. Farval now does the job for $400 a month. The eight oilers were cut to two, who also keep the Farval systems filled and operating around the clock.

The money savings in labor and lubricant average $1910 a month. Yet gratifying as these dollar savings are, this user says the elimination of the former mill delays due to hot bearings has given the company an even larger return in increased mill output—far more valuable than all other economies combined. All this from an original investment in Farval centralized lubricating systems of less than $7500!

Farval delivers oil or grease under pressure to a group of bearings from one central station, in exact quantities, as often as desired. Farval —the Dualine System with the Positive Piston Displacement Valve—that has but 2 Moving Parts—is Fully Adjustable—and with a Tell-tale indicator at each bearing to show the job is done.

Savings comparable to the above can be made on your equipment with Farval. Write for Bulletin 25. The Farval Corporation, 3265 East 80th Street, Cleveland 4, Ohio.

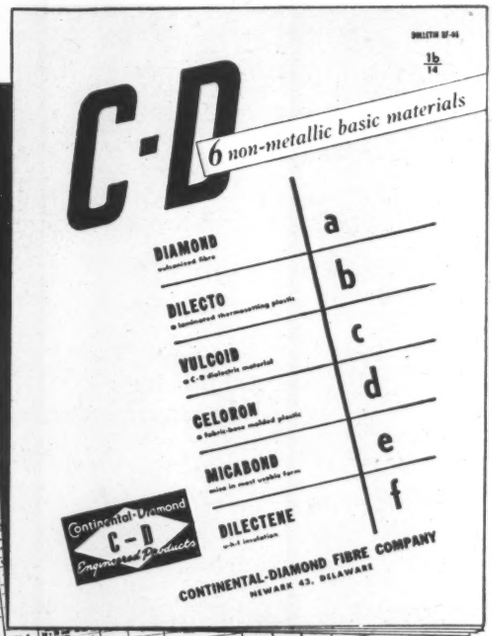
*Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.*

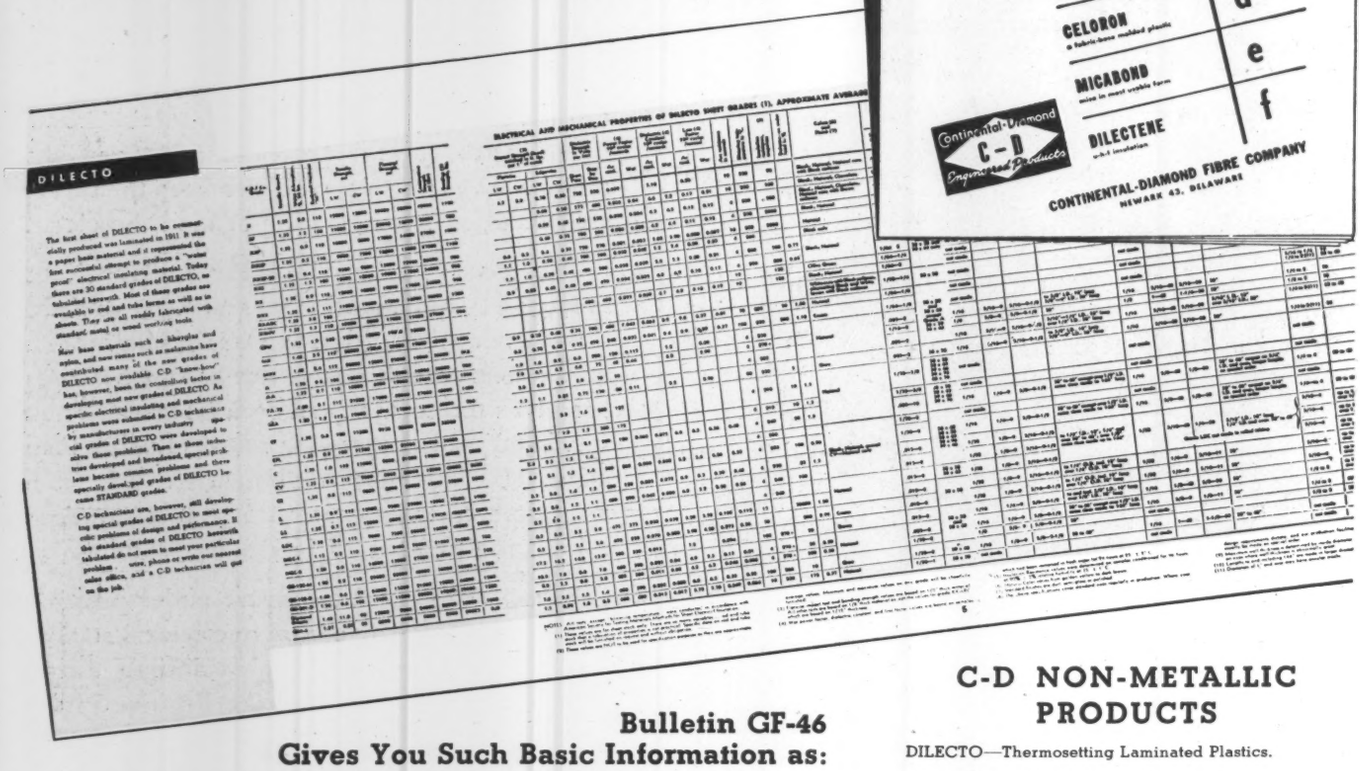


# WHAT ARE *Your* QUESTIONS About Electrical Insulating Materials?

You're building a good product—but want to make it better . . . you want to improve its electrical characteristics . . . improve its overall performance. Among 38 grades of the 6 C-D non-metallics, there is a grade that will do the trick. But, the question is, which one possesses the properties you require.

To give you such information, C-D technicians have put together valuable engineering data in the new GF-46 Bulletin. It tells you all you need to know about how to select and apply non-metallics for most efficient electrical insulating purposes. Send for it today.




## Bulletin GF-46 Gives You Such Basic Information as:

- Physical Properties
- Electrical Properties
- Composition of Material
- Recommended Uses
- Grades, Types and Sizes
- Fabrication Information

If your need for help on insulation problems is urgent, phone or wire our nearest office and a C-D technician will be around to see you—quickly.

Continental-Diamond C-D Engineered Non-metallics

DE-1-47

## C-D NON-METALLIC PRODUCTS

DILECTO—Thermosetting Laminated Plastics.

CELORON—A Molded Phenolic Plastic.

DILECTENE—A Pure Resin Plastic Especially Suited to U-H-F Insulation.

HAVEG—Plastic Chemical Equipment, Pipe, Valves and Fittings.

DIAMOND Vulcanized FIBRE.

VULCOID—Resin Impregnated Vulcanized Fibre.

MICABOND—Built-up Mica Electrical Insulation.

**STANDARD & SPECIAL FORMS**

Available in Standard Sheets, Rods and Tubes; and Parts Fabricated, Formed or Molded to Specifications.

**DESCRIPTIVE LITERATURE**

Bulletin GF gives Comprehensive Data on all C-D Products. Catalogs are also available.

BRANCH OFFICES: NEW YORK 17 • CLEVELAND 14 • CHICAGO 11 • SPARTANBURG, S. C. • SALES OFFICES IN PRINCIPAL CITIES
WEST COAST REPRESENTATIVES: MARWOOD LTD., SAN FRANCISCO 3 • IN CANADA: DIAMOND STATE FIBRE CO. OF CANADA, LTD., TORONTO 8

**Continental-Diamond FIBRE COMPANY**

*Established 1895..Manufacturers of Laminated Plastics since 1911— NEWARK 23 • DELAWARE*

# You can make a *better product* with DODGE STEEL CASTINGS

Here are some of the advantages you get:

Close dimensions—less machining and finishing to do.

Wide range of physical properties—to suit special needs.

Steel selected for high stresses, high pressures, high temperatures.

Heat treatments to enhance the natural properties of steels.

Co-operation in producing economical and practical designs.

Let's talk it over.

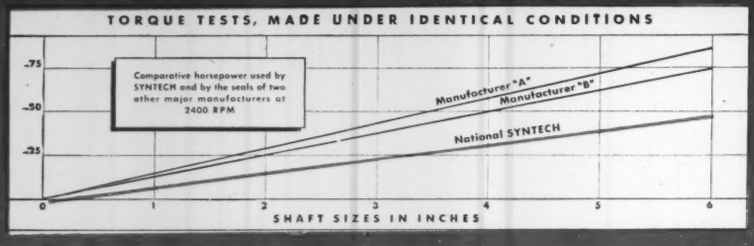
D S

**DODGE STEEL CASTINGS**

***DODGE STEEL COMPANY • TACONY, PHILADELPHIA 35, PA.***

# Syntech*

## New National Oil Seal shatters all records in performance...Gives 100% longer life, 70% less drag, zero leakage

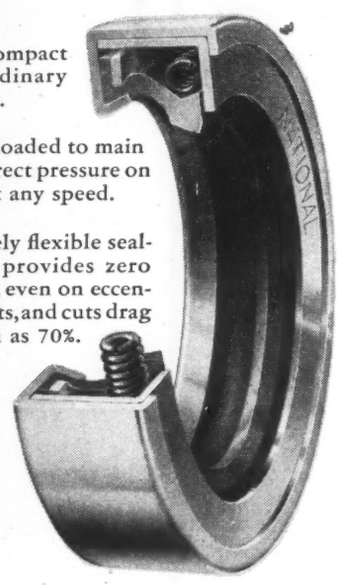



**SYNTECH** (trademark registered) is an entirely new oil seal which utilizes a special National-developed, synthetic-rubber sealing member.

1 More compact than ordinary oil seals.

2 Spring-loaded to main tain correct pressure on shafts at any speed.

3 Extremely flexible sealing lip provides zero leakage, even on eccentric shafts, and cuts drag as much as 70%.



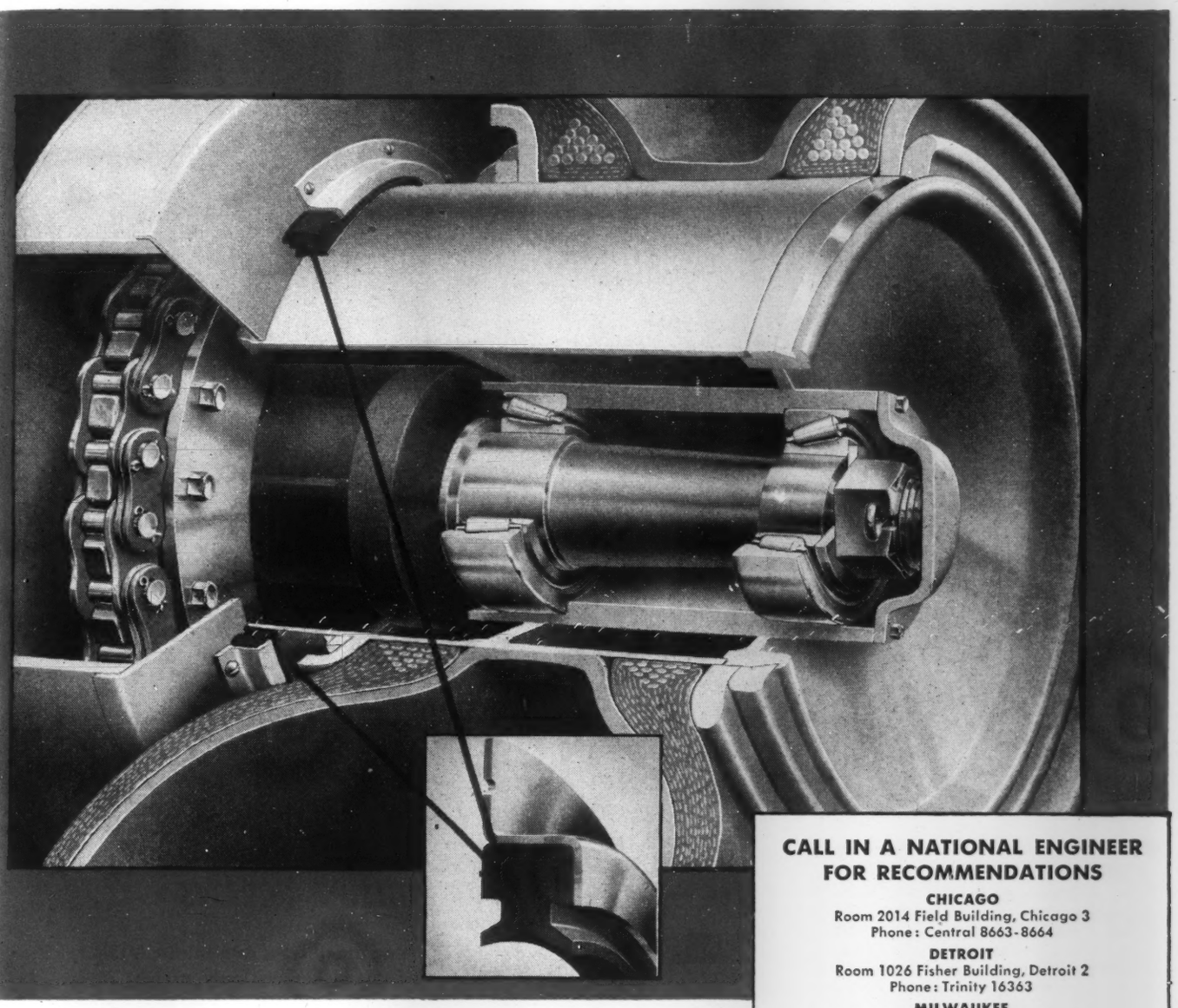

**SYNTECH** is made of synthetic rubber compounded to achieve high flexibility and low coefficient of friction.

Design of sealing lip provides limited shaft contact.

This thin section assures maximum flexibility of the sealing member.

Arduous road and dynamometer tests prove positively that the new National SYNTECH Oil Seal is head and shoulders above the field. Safety and economy factors of abrasion, wear, speed and runout far exceed those found in any other seals tested. Optimum results are obtained and marked reduction in power wastage is made possible by lower torque. And tests conclusively show that National SYNTECHS performed at zero leakage over periods up to 10 times the life of a normal application. This effectively blasts the theory that a seal must allow seepage to achieve long life.

Get in touch with National today—for more information and samples of the amazing new SYNTECH. National SYNTECHS are available in any size, for any operation. They represent a great engineering triumph in the field of lubricant retention.



## A special 28" O. D. Syntech seal does the ideal job on this scraper's power take-off

A leading road machinery manufacturer recently brought us one of the toughest problems we've ever solved. He needed a rugged, long-lasting seal with a relatively monstrous O.D. His application was the power-drive housing of his heaviest road scraper, where mud, dust and rocks hand out a terrific daily beating to any oil retainer.

National engineers custom-designed a National SYNTECH Oil Seal capable of withstanding the hard knocks received by this equipment. Measuring just over 28" in diameter, this specially-designed SYNTECH permitted the scraper to turn in months of continuous performance. Not a day was lost by breakdown attributable to oil seal failure.

On-the-job performance like this demands respect. Let National engineers assist you with your problem. Give us the complete details so we can be of maximum help. Your application will be kept in strictest confidence.

**NATIONAL MOTOR BEARING COMPANY, INC.**
**General Offices: Redwood City, California**
**Plants: Redwood City and Los Angeles, California; Van Wert, Ohio**

**CALL IN A NATIONAL ENGINEER FOR RECOMMENDATIONS**

**CHICAGO**
Room 2014 Field Building, Chicago 3
Phone: Central 8663-8664

**DETROIT**
Room 1026 Fisher Building, Detroit 2
Phone: Trinity 16363

**MILWAUKEE**
1717 E. Kane Place, Milwaukee 2
Phone: Lakeside 2838

**SPRINGFIELD, MASS.**
124 State Street, Springfield 3, Mass.
Phone: Springfield 2-1881

**PHILADELPHIA**
401 North Broad Street, Philadelphia 8
Phone: Bell-Walnut 2-6997—6998

**NEW YORK CITY**
122 East 42nd Street, New York City 17
Phone: Lexington 2-8260

**CLEVELAND**
210 Heights Rockefeller Building, Cleveland 18
Phone: Yellowstone 2720

**HOUSTON**
1 Main Street, Houston 2, Texas
Phone: Preston 9862

**KANSAS CITY, MO.**
1823 Walnut Street, Kansas City 8, Mo.
Phone: Harrison 6637

**NATIONAL**
**OIL AND FLUID SEALS**

WHEREVER SHAFTS MOVE, THERE'S A NATIONAL SEAL TO RETAIN THE LUBRICANT

# Furniture Builders are "Sitting Pretty"

## AND SO ARE THEIR CUSTOMERS...

4-WINGED DRIVER CAN'T SLIP OUT OF PHILLIPS TAPERED RECESS

## ... when Costs are Cut — Appearance and Durability improved — by AMERICAN PHILLIPS SCREWS

**IN THE FACTORY:** The most modern fastening for all types of furniture is the American Phillips Screw. Easy to handle . . . lightning-fast and automatically straight to drive . . . fumble-proof, slip-proof and damage-proof . . . American Phillips Screws deliver top savings on any fastening job in any type of plant from furniture to railroad cars. Put these engineered screws on *your* costs — *and watch your time-savings shoot up as high as 50%!*

**IN THE SALESROOM:** One of the hallmarks of fine furniture and other household appointments is the decorative, straight-set, unburred head of the American Phillips Screw. More and more quality-minded buyers look for this distinctive feature—*both* for the sake of appearance, and as a *visible assurance* of sturdy construction and long service—their money's worth and then some! *Your* product should have this cost-cutting, sales-building advantage.

**AMERICAN SCREW COMPANY, PROVIDENCE 1, RHODE ISLAND**

*Chicago 11:* 589 E. Illinois St. *Detroit 2:* 502 Stephenson Bldg.

# AMERICAN PHILLIPS *Screws*

**ALL TYPES**

**ALL METALS: Steel, Brass, Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)**

# HOW MUCH and HOW MANY

## *Are Basic Questions in*

# POWDER METALLURGY

On the basis of "How Much?" metal powder parts from Moraine have replaced parts produced by conventional methods in scores of applications. They have effected substantial savings in cost through the elimination of secondary machining operations, and provided the fine finish and close practical tolerances required by the customer.

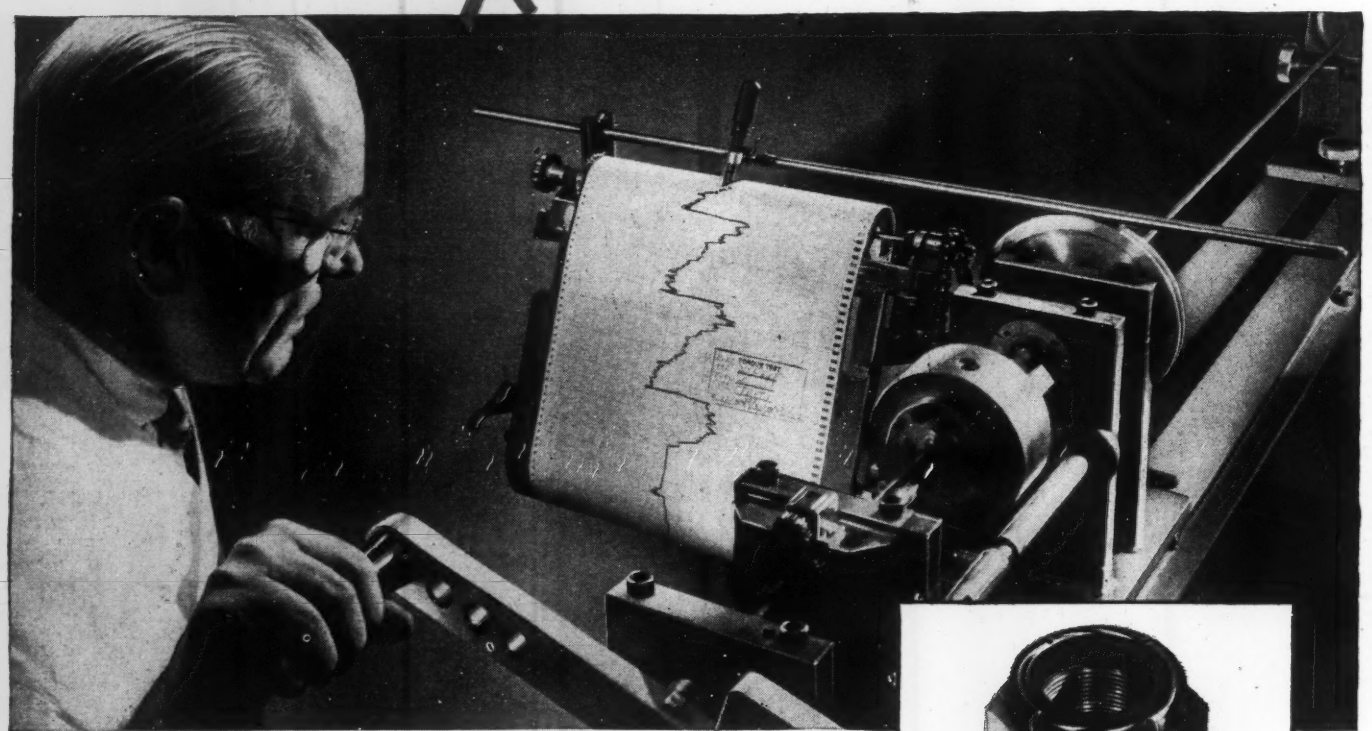
Before costs can be determined, however, another question must be answered: "How Many?" Production by powder metallurgy is economical mainly in large, continuing runs. It does not lend itself to job-lot orders, but requires good volume to justify the cost of tooling and setup.

If your answer to "How Many?" is a volume figure, we believe we can give you a satisfactory answer to "How Much?" Moraine Products' experience in powder metallurgy is at your service to supply better parts at lower cost.

**MORAINE PRODUCTS** DIVISION OF **GENERAL MOTORS**

**DAYTON, OHIO**

# A-N TORQUE TESTS *Prove Reusability* OF ELASTIC STOP NUTS



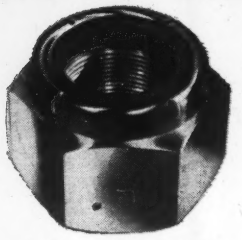
## *—the Red Elastic Collar provides dependable locking torque for* RE-USE!

Army and Navy specifications for aircraft lock nuts include a specific torque test to prove locking effectiveness. Lock nuts have to maintain adequate locking torque through 15 on-and-off cycles.

ESNA Elastic Stop Nuts—with the Red Elastic Collar that has become a symbol of security to all aviation engineers—remain self-locking against Vibration, Impact and Stress Reversal in both pre-stressed and positioned settings.

In addition, the self-locking, self-sealing and reusable Red Elastic Collar protects the bolt. It does not deform the bolt, damage the threads or gall the finish.

Reusable ESNA Elastic Stop Nuts provide dependable protection against Vibration, Thread Corrosion, Thread Failure, and Liquid Seepage. This multiple protection—which has made Elastic Stop Nuts the standard fastener on many products—also achieves the double economy of inventory simplification and reduced procurement costs. ESNA engineers are now ready to study your fastener problems. Address: Elastic Stop Nut Corporation of America, Union, New Jersey. Sales Engineers and Distributors are conveniently located in many principal cities.



**The RED ELASTIC COLLAR**

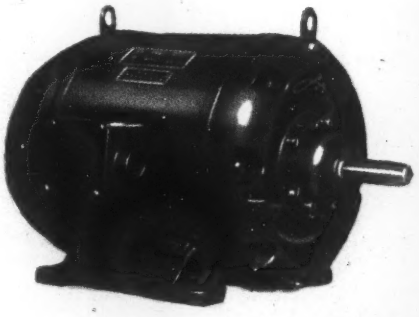
— denoting an ESNA product —

. . . is threadless and dependably elastic. Every bolt — *regardless of commercial tolerances* — impresses (does not cut) its full thread contact in the Red Elastic Collar to fully grip the bolt threads. In addition, this threading action properly seats the metal threads — and eliminates all axial play between bolt and nut threads.

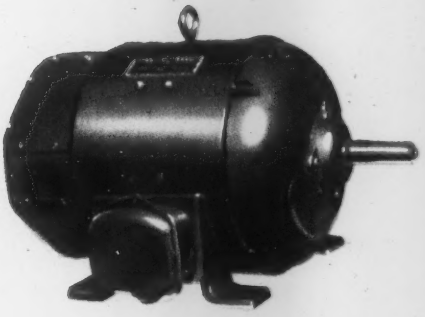
Torque tests — for Elastic Stop Nuts — are based on a steel-to-steel frictional coefficient of .18. Bolt loadings are figured at 40,000 psi for commercial bolts; 90,000 psi for aircraft bolts.

# ELASTIC STOP NUTS

***PRODUCTS OF:*** ELASTIC STOP NUT CORPORATION OF AMERICA



*There is a size and type* **LOUIS ALLIS** *electric motor for every industrial requirement.*



# *Your Electric Motor Requirements*

**The day of trying to use a standard motor for a special job is about over.**

***Machinery designers, and production managers have learned that it is much more efficient and economical to obtain a motor with exactly the electrical and mechanical characteristics required to perform a specific job than it is to try to doctor up a standard "shelf" motor to do the job.***

**Speed and horsepower are no longer the major measuring stick of motor requirements—they are merely incidental to the many other characteristics available in electric motors today.**

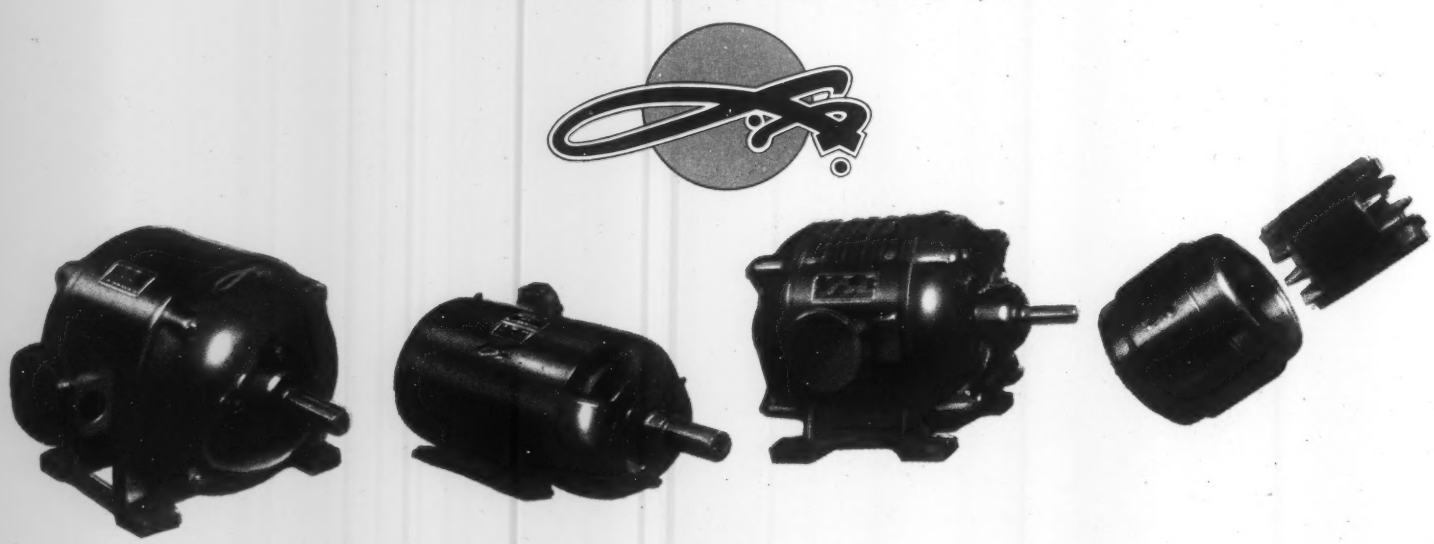
***For over forty years we have been developing special motors for special jobs—our engineering department has a wealth of experience along this line—***

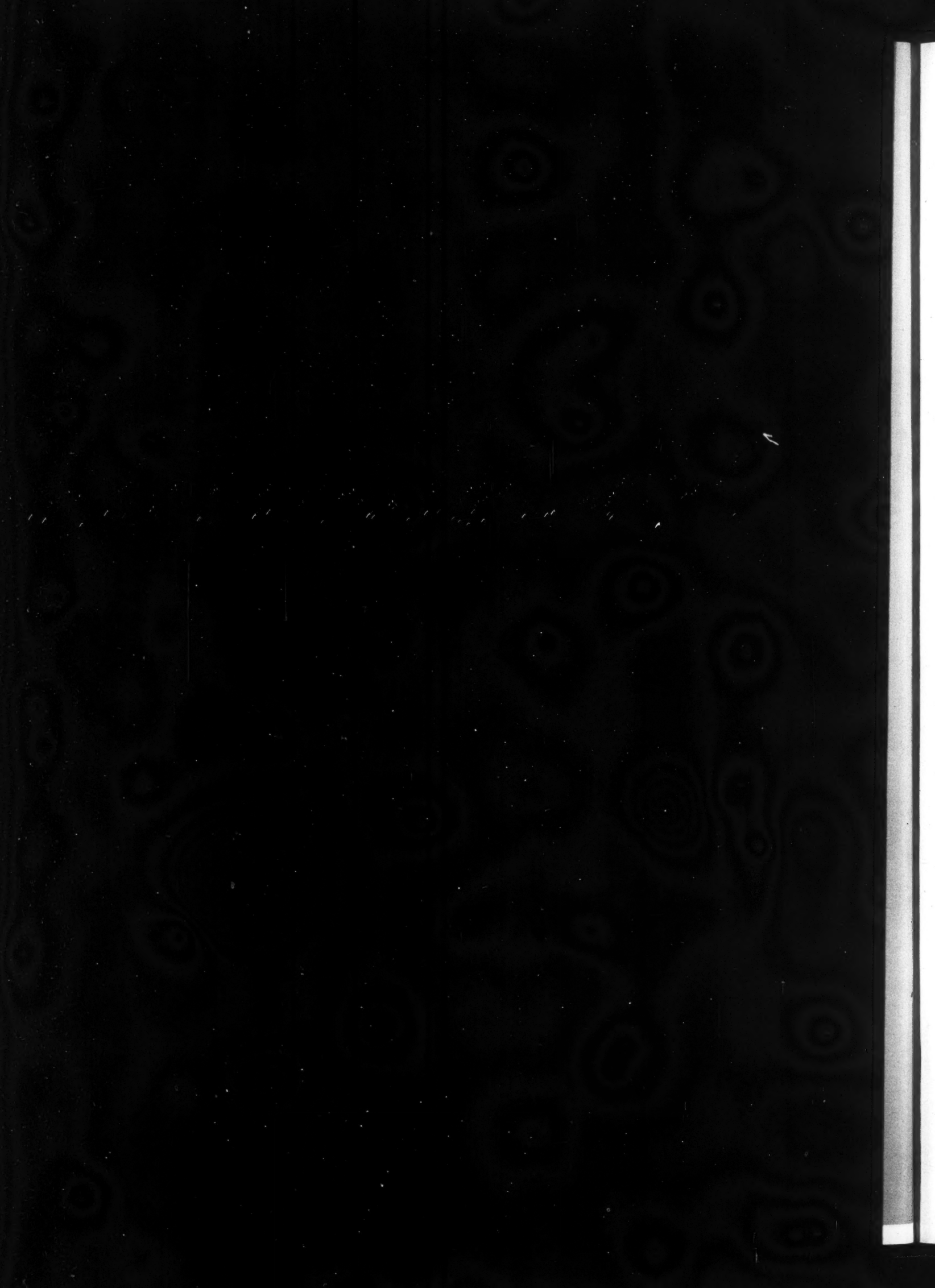
**Our engineering development department has created many outstanding — perhaps revolutionary — improvements in electric motor design, construction and performance — motors that have given a splendid account of themselves on highly specialized jobs for many years.**

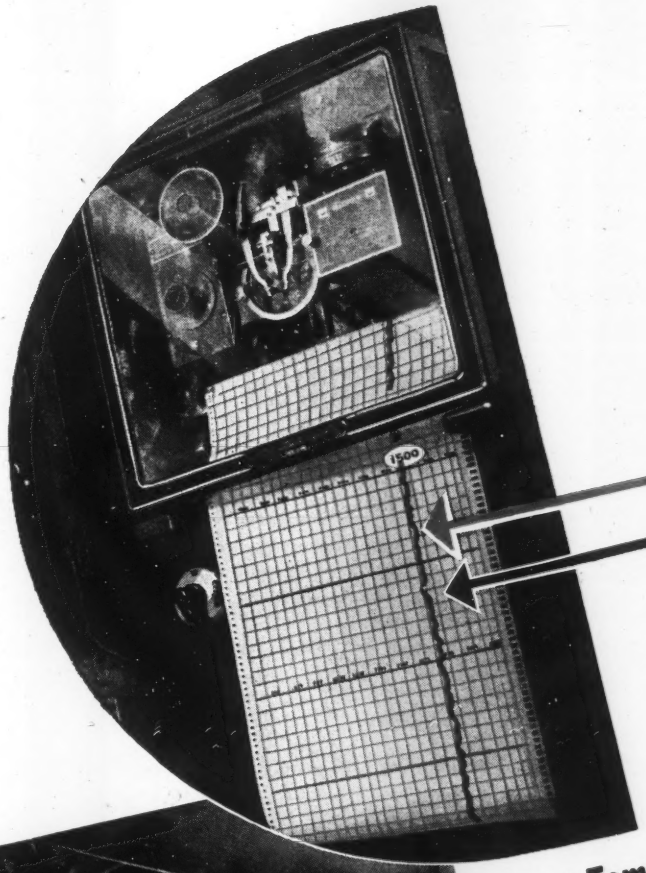
**The same careful and exacting design, engineering and construction that have made LOUIS ALLIS special motors famous for their dependability is also reflected in all Louis Allis STANDARD motors.**

**Our engineering development department will welcome the opportunity of discussing your special electric motor problems with you.**

***THE LOUIS ALLIS CO., MILWAUKEE 7, WIS.***







# too HOT at 1505°

# too COLD at 1495°

## ...but Temperatures are held JUST RIGHT in heat treating PERMITE Steel Parts

Precision control in the heat treating department is a major factor in giving you the exact physical properties you want in your Permite Steel Parts. Permite heat treating furnaces are controlled to ±5° F. on all predetermined temperature ranges for the proper heat treating of the particular steel or part. This same exactness of control extends to temperature time, atmosphere and quench media in Permite heat treating operations.

A Permite piston pin, bolt, bushing, shaft or other steel part is a superior part because of the quality control exercised in every step of its manufacture. This quality control safeguards the Permite reputation for dependable performance in all types of automotive, aircraft and industrial applications.

Ask for full information on Permite precision-made steel parts, and Permite facilities for serving you.

PERMITE

**ALUMINUM INDUSTRIES, INC.**

CINCINNATI 25, OHIO

DETROIT: 809 New Center Building. NEW YORK: 9 Rockefeller Plaza. CHICAGO: 64 E. Jackson Boulevard. ATLANTA: 413 Grant Building

ALUMINUM PERMANENT MOLD, SAND and DIE CASTINGS...HARDENED, GROUND and FORGED STEEL PARTS

# BY SPECIFYING

UNBRAKO

Reg. U. S. Pat. Off.

## SCREW PRODUCTS

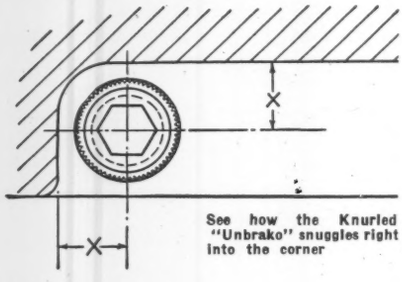
Knurling of Socket Screws originated with "Unbrako" in 1934.

## YOU SAVE *Space and Weight*

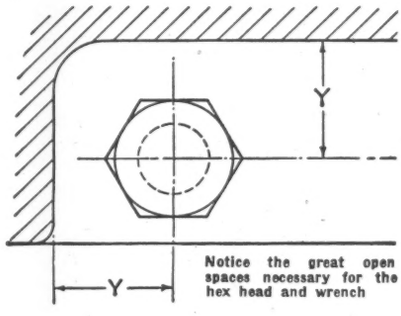
The diagram shown below illustrates a common form of bolted joint, and the material savings in space and weight made possible when you use the "Unbrako" Socket Head Cap Screw with the Knurled Head (A). Its internal wrenching feature facilitates compact design, thereby, saving space and reducing weight. Its knurled head speeds assembly, because the knurling provides a slip- and fumble-proof grip . . . though the fingers and heads be ever so oily, therefore, this screw can be screwed-in faster and farther before it becomes necessary to use a wrench. Available in sizes from #4 to 1½" in diameter . . . lengths in a full range.

Write for your copy of the "Unbrako" Catalog.

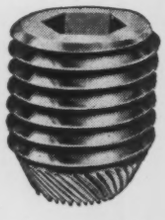
**"Unbrako" and "Hallowell" Products are sold entirely through distributors.**




See how the Knurled "Unbrako" snuggles right into the corner




Notice the great open spaces necessary for the hex head and wrench



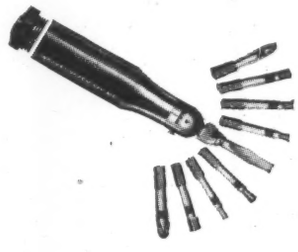
Pat'd. and Pats. Pend.

The knurled Cup Point of the "Unbrako" Socket Set Screw makes it a Self-Locker—the point digs in and holds fast, even when subjected to the most chattering vibration.

Pat'd. and Pats. Pend.

The knurled threads of this "Unbrako" Socket Set Screw makes it a Self-Locker, too, for use where the point does not lend itself to knurling.

This "Unbrako" Socket Set Screw is strong, accurate and dependable. Millions are in use.



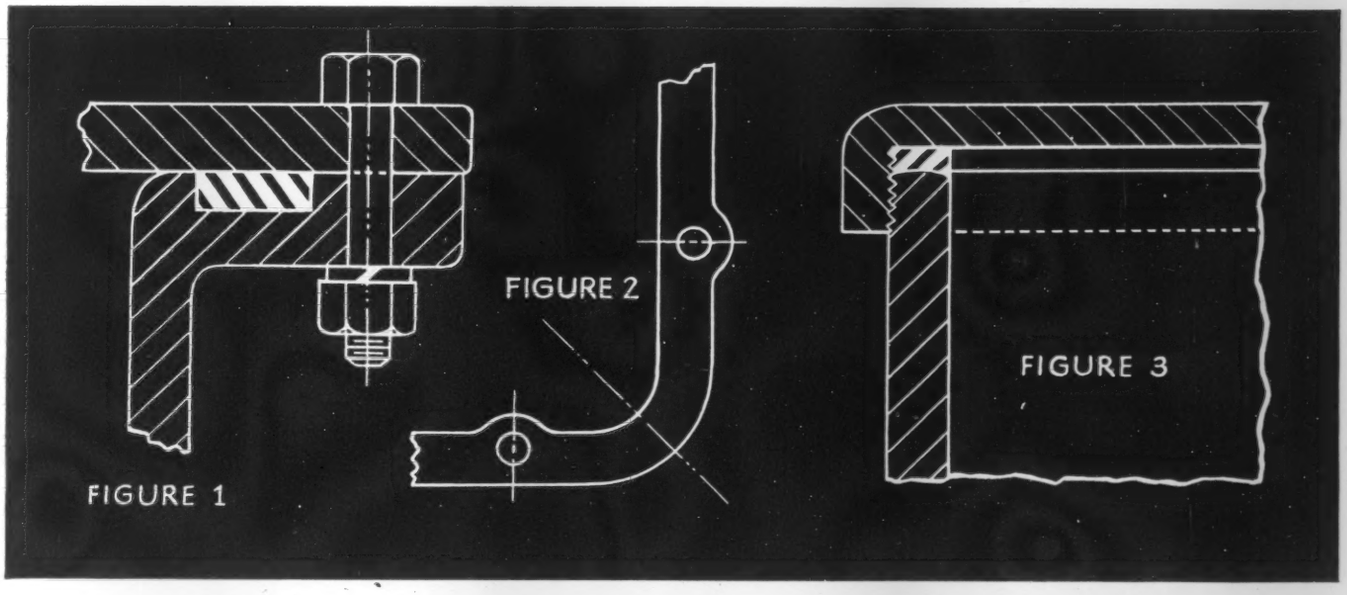
Kits: Pats. Pend.

You can't screw socket screws in or out without a hex socket wrench, so why not get our No. 25 or No. 50 "Hallowell" Hollow Handle Key Kit which contains most all hex bits.

OVER 44 YEARS IN BUSINESS

**STANDARD PRESSED STEEL CO.**

JENKINTOWN, PENNA., BOX 102 • BRANCHES: BOSTON • CHICAGO • DETROIT • INDIANAPOLIS • ST. LOUIS • SAN FRANCISCO




# DESIGNING FLANGES FOR EFFICIENT SEALING

## *Mechanically correct joints prevent most gasket specification difficulties*

Since the satisfactory functioning of a unit may depend upon maintaining a tight seal at some point, that seal merits the same care and forethought as any other aspect of a design. To neglect gasketing problems until a unit is built and ready for testing is to invite inefficient, makeshift sealing. When this imposes excessive demands on a gasket, chronic service difficulties are likely to result.

By contrast, an effective seal at the lowest consistent cost is relatively easy to attain when a joint is designed to meet the requirements not only of the unit itself, but also of the probable resilient material to be used in it. Consequently, flange design is perhaps the first factor to be considered in arriving at a gasket specification.

The kind of joint needed is determined by the requirements of the unit. For example, precise alignment of internal parts may demand a metal-to-metal design. In that event, an offset flange may be required to allow for a gasket channel (Figure 1). For use with non-compressible gaskets, such as straight rubber, a relief for side flow must be provided. No relief is needed for cork-and-rubber gaskets.

Flange finish must be considered in relation to the type of gasket material demanded by operating conditions within the assembly. If a soft, resilient material can be used, it may be economical to leave the flange relatively rough. The gasket will fill in any normal irregularities. On the other hand, if close alignment is needed, a smooth flange will be necessary to get a tight seal with the thin gasket required for close-tolerance assembly.

Bolt holes or studs should not be too large in relation to the cross-sectional area of the gasket. Thin wall sections may blow out if internal pressure is present. Furthermore, large holes make a gasket fragile and hard to handle during assembly. On a narrow flange, gasket walls may be widened at bolt holes by adding either inside or outside "ears" as illustrated above (Figure 2).

When a sealed edge is brought into contact with a gasket by torsion, that edge should be made smooth to avoid cutting the gasket (Figure 3).

An Armstrong representative will be glad to call and discuss your specific sealing problem with you. Because of his diversified gasketing experience, he may be able to suggest design modifications that will save both time and expense in arriving at a satisfactory seal. He will also suggest suitable gasket materials and supply samples for testing in experimental units. A district office is conveniently near you.

If you prefer, send drawings and complete details to us. You will find our recommendations unbiased and keyed to good current gasketing practice.

**SEND FOR FREE BOOKLET.**

For specification and application data on Armstrong's more than 50 resilient sealing materials, send for a free copy of the latest edition of "Gaskets, Packings, and Seals," twelve pages of helpful information. Address Armstrong Cork Company, Gaskets and Packings Department, 5103 Arch Street, Lancaster, Pennsylvania.

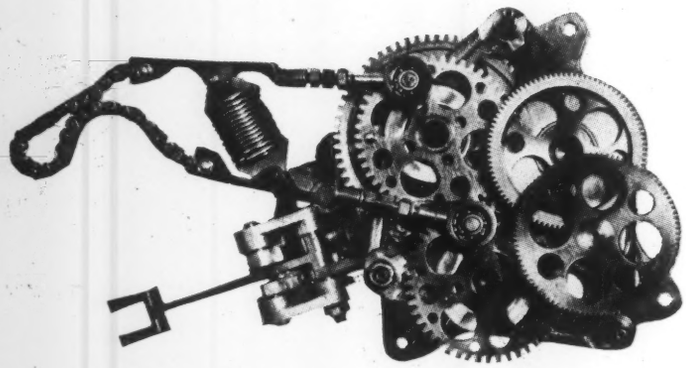
**ARMSTRONG'S**
**GASKETS · SEALS · PACKINGS**

Cork Compositions • Cork-and-Synthetic-Rubber Compositions
Synthetic Rubber Compounds • Cork-and-Rubber Compositions
Fiber Sheet Packings • Rag Felt Papers • Natural Cork

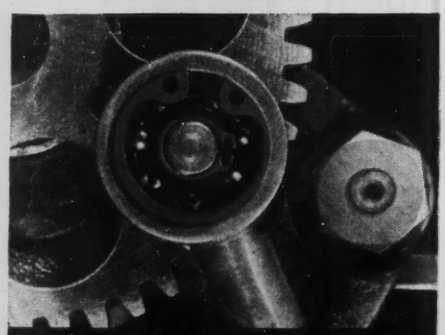
# 36 TRUARC rings reduce weight, eliminate

## • Waldes Truarc retaining rings cut machining, assembly, maintenance time

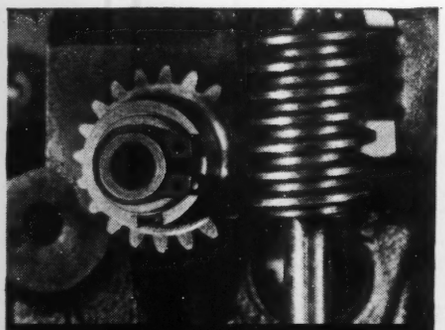
Tiny rings easily installed, keep link pins in position, are easily removed for repairs.



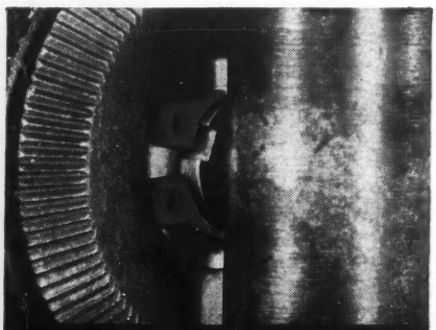
Courtesy of Dalmo-Victor



Truarc snaps in place easily as a ball-bearing retainer, allows shorter bushing.



Gears stay secure: Truarc saves space in this gear and worm application.



Assembly in cramped space with practically no clearance is simplified with Truarc ring.

"TRUARC NOT ONLY REDUCES WEIGHT IN OUR APS-4 AIRCRAFT ANTENNA," states Dalmo-Victor, of San Carlos, California, "but also saves numerous machining, drilling and threading operations and reduces assembly and maintenance time. Waldes Truarc Retaining Rings are easy to install and remove, give equal pressure over a continuous surface because of their perfect circularity, and eliminate large numbers of tools hitherto required. They do not deteriorate under the most rigorous operating conditions."

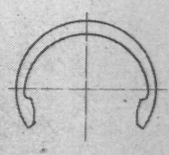
# parts in complex radar aircraft antenna!

Wherever permanent maintenance of tolerance is important, Truarc rings keep moving parts in accurate relationship. In all industries, designers find Truarc a better way of fastening machine parts; production and maintenance men find Truarc cuts costs.

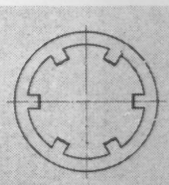
**There are different Truarc rings for any need,** in a complete range of sizes, for internal or external use. For example, there are Truarc rings that can be applied radially where axial assembly is impossible. Another type of ring is designed to take up end-play. Whatever your specifications, there's a Truarc ring that will do your fastening job better than screws, bolts, machined shoulders or cotter pins. Waldes Truarc engineers will be glad to assist in solving your problems. Send us your drawings; see how Truarc can help you.

**INTERLOCKING . . . 2-piece ring takes heavy thrusts, gives positive lock against high RPMs.**

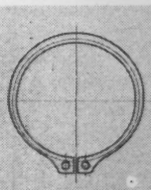
**INVERTED . . . Gives uniform shoulder for curved surfaces, for bearings with large corner radii.**



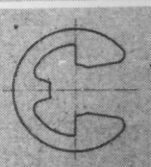
**CRESCENT*: Snaps on radially where axial assembly is impossible. No special tools are required.**



**SELF-LOCKING: Economical where thrust is moderate—holds fast, yet shaft requires no machining.**



**BEVELED & BOWED: Takes up end-play rigidly or resiliently, accommodates accumulated tolerances.**



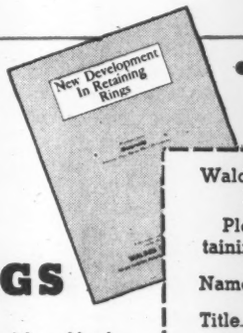
**E-RING: Variant of Crescent for small shafts; provides large, strong shoulder. Easily removed.**

**WALDES TRUARC**

U. S. PATENT RE. 18,144 AND OTHER PATS. PEND.

**RETAINING RINGS**

WALDES KOHINOOR, INC., Long Island City 1, New York




● *Send for New Truarc booklet, "New Development in Retaining Rings"*

Waldes Kohinoor, Inc., 47-10 Austel Place 21-L
Long Island City 1, N. Y.

Please send booklet, "New Development In Retaining Rings" to:

Name_____

Title_____

Company_____

Business Address_____

City_____ Zone____ State_____

*U.S. Patent 2,382,948

# the permanent wave

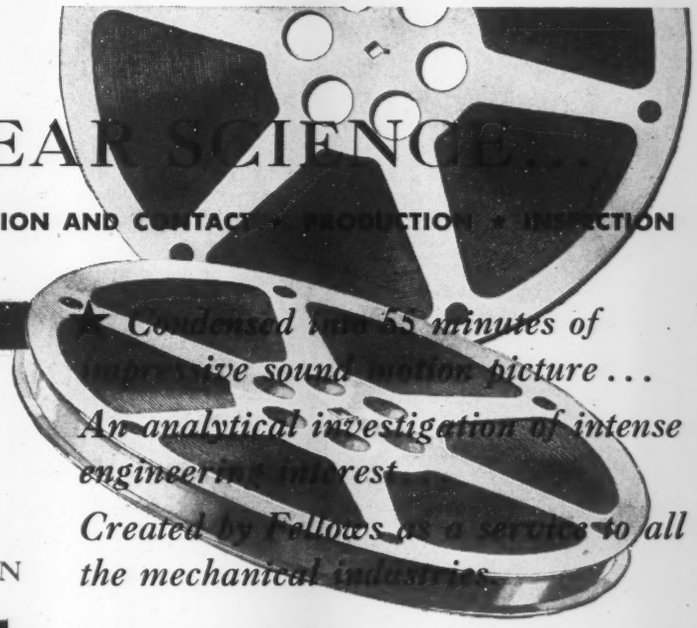
DOUBLES THE WATTAGE RATING

The patented crimp Ward Leonard puts in Ribflex resistance ribbon gives a greater area for faster heat dissipation. Size for size, Ribflex Resistors have 85% to 95% greater wattage rating than ordinary wire-wound resistors—making them ideal for both continuous and intermittent duty. Write for Bulletin 19. Ward Leonard Electric Co., Mt. Vernon, N. Y. Offices in principal cities of U. S. and Canada.

**WARD LEONARD ELECTRIC CO.**

# *The Latest in* GEAR SCIENCE...

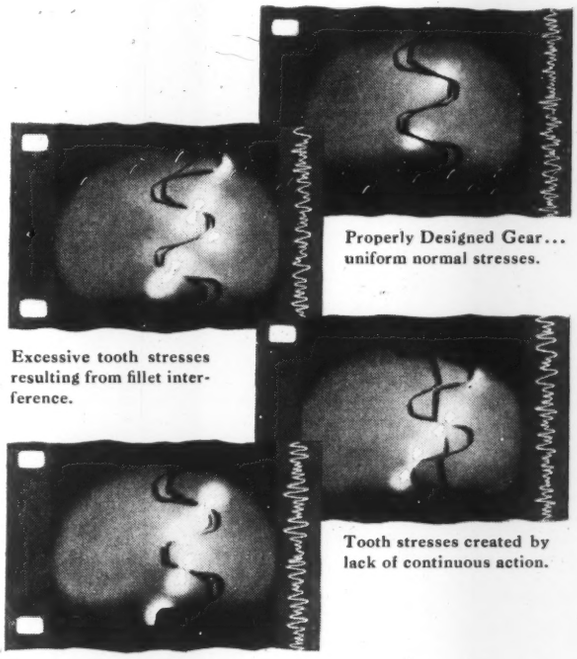
**DESIGN ★ THEORY ★ TOOTH ACTION AND CONTACT ★ PRODUCTION ★ INSPECTION**



★ *Condensed into 55 minutes of impressive sound motion picture . . .*
*An analytical investigation of intense engineering interest*
*Created by Fellows as a service to all the mechanical industries*

*Now for the First Time*

POLARIZED LIGHT shows the NATURE of GEAR TOOTH ACTION



Properly Designed Gear... uniform normal stresses.

Excessive tooth stresses resulting from fillet interference.

Tooth stresses created by lack of continuous action.

Tooth stresses caused by involute interference.

A dancing point of light traces the line of action as teeth pass into and out of mesh. Normal tooth contact stresses shine, but abnormal tooth contact stresses flash their presence, location, and the comparative degree of excessive strain. You see *why* imperfect gears have failed... you see *where* design corrections can be made. And this is only one of the many demonstrations to excite the gear designer.

Designers will find many stimulating new ideas. Gear theory is explored with novel animations and specimen gears of transparent lucite. Gear tooth action and stresses in perfect and imperfect gears are brought to light in striking and unique demonstrations. Even life-long gear men have been amazed.

Complete inspection techniques and the newest gear production methods are grouped as the subject matter of Reel II. Throughout both reels the sound commentary provides the explanatory narrative. Appointments can be made through our local offices for private showings free of charge. For further particulars, consult the Publicity Department, the Fellows Gear Shaper Company, Head Office and Export Dept., Springfield, Vermont, U.S.A. Branch Offices...616 Fisher Bldg., Detroit 2 or 640 West Town Office Bldg., Chicago 12.

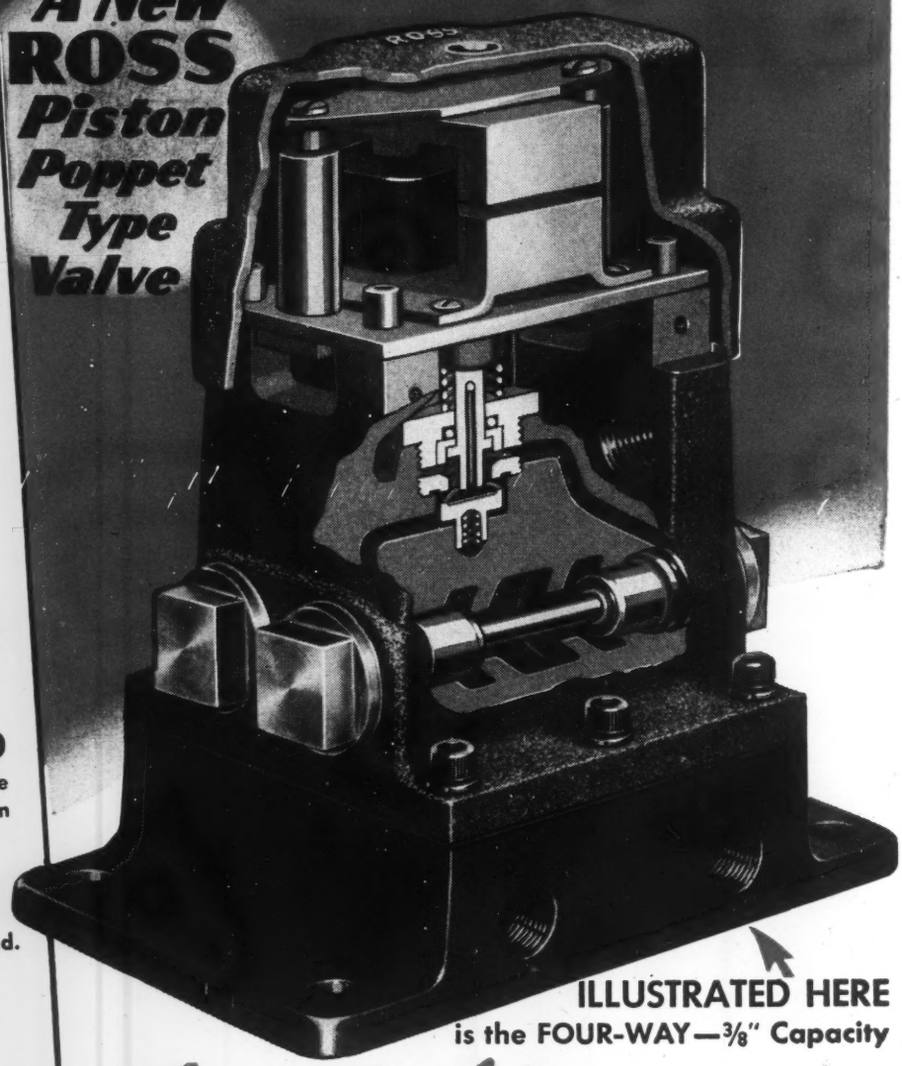
**Fellows**

**THE FELLOWS METHOD...MACHINES AND TOOLS FOR ALL OPERATIONS FROM BLANK TO FINISHED GEAR**

# The Air Valve You Have Been Looking For

# PILOT OPERATED · SOLENOID CONTROLLED

**A New ROSS Piston Poppet Type Valve**




**ILLUSTRATED HERE**
is the FOUR-WAY—3/8" Capacity

- **FAST OPERATING** as high as 400 cycles per minute.
- **LARGE ORIFICE AREA** results in fast exhaust, minimum restriction to air flow.
- **POSITIVE SEAL** by line pressure.
- **SIMPLICITY OF DESIGN** removing end plugs permits replacement of piston poppet assembly—no need to disturb piping or to move valve from position—no "down time".
- **ECONOMICAL TO OPERATE** current consumption 1.2 amps. at 110 volts—60 cycle.
- **LONG SERVICE ASSURED** many Ross valves installed more than 20 years ago are still in active service.
- **SMALL AND COMPACT** appreciated where space is limited.
- **ALL PARTS** non-corrosive metals.
- **ACCURATELY MACHINED** and all parts interchangeable.

## Available in:—

- **THREE-WAY** *normally open, or normally closed*
- **FOUR-WAY** *and*
- **FOUR-WAY,** *Five port.* *may be had in 1/4", 3/8", 1/2" and 3/4" pipe size*

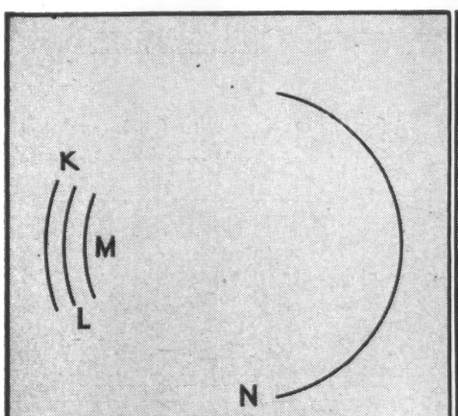
**ROSS Air Control VALVES**

A TYPE AND SIZE FOR EVERY PURPOSE
★
OVER 100 DIFFERENT MODELS

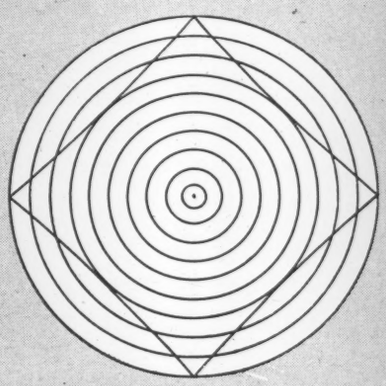
THE BRIDLE FOR AIR HORSEPOWER

**ROSS Operating VALVE CO.**
6485 Epworth Blvd. Detroit 10, Mich.

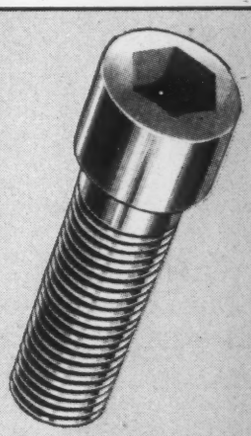
# Can You Always Believe Your Eyes?




**A. If circle N were completed, would it meet K, L, or M?**



**B. Are the heavier lines above really straight, or curved?**



**C. What size is this Socket Screw?**

Some things aren't always what they seem to be – even to experienced eyes. The size and thread pitch of the socket screw above, for example, were guessed wrong by many of the shop men questioned in a recent test. On the job, that means they must take *time out* to *find out.*

## *There isn't any question...*

## WHEN IT'S SIZE-MARKED

Any assembly worker can spot the right size without effort – no need to waste time – no need to guess and risk errors. The correct size is clearly marked on the head.

At the tool-crib, left-over, mixed-up screws are quickly sorted and put back in the proper bins, without slow "miking" or gauging.

*A valuable sales feature, too.* Ask any maintenance man who service your product after it's sold. He'll appreciate P-K Size-Marked Screws because he can easily tell which ones go where when reassembling.

### *Plus* – GEAR GRIP*

Gear Grip makes Size-Marked Screws slip-proof, even when fingers are oily. Only Parker-Kalon offers Socket Head Cap Screws with both features. Write for samples, today. Parker-Kalon Corporation, 200 Varick Street, New York 14, New York.

***ANSWERS***

**A. N and M are arcs of the same circle.**
**B. The lines are curved.**
**C. When it's P-K Size-Marked, there's no question!**

*U. S. PAT. No. 126,409

ANOTHER **P-K** FIRST

**GROUND THREAD**
**Socket Set Screws**

● Smooth, mirror-bright, clean finished threads – centerless ground on hardened blanks. Accurate contour and lead, dependable Class 3 Fit. Free from imperfections common to ordinary cut thread set screws . . . a "shining example" of good workmanship. Ask for samples. You'll see the difference.

**P-K SOCKET SCREWS ARE AVAILABLE FOR PROMPT DELIVERY!**
*Send for Stock List Now*

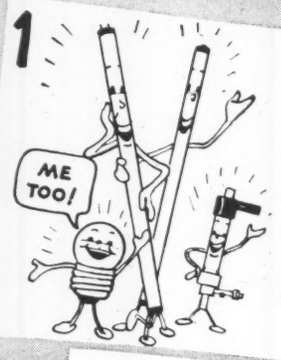
SOLD ONLY THROUGH ACCREDITED DISTRIBUTORS

**PARKER-KALON** *Cold-forged* **SOCKET SCREWS**

# Are you in the know on GLOW?

**THESE QUICK FACTS ON G-E NEON GLOW LAMPS MAY HELP YOU PRODUCE A MORE SUCCESSFUL PRODUCT**

1




**QUESTION**—What is a neon glow lamp? What makes it glow?

**ANSWER**—It is the "baby" of the electrical discharge lamp family—and consists of twin electrodes sealed within a bulb containing neon gas. When the gas is ionized by application of a voltage, an orange-red glow covers the cathode.

2

**QUESTION**—How are glow lamps used?

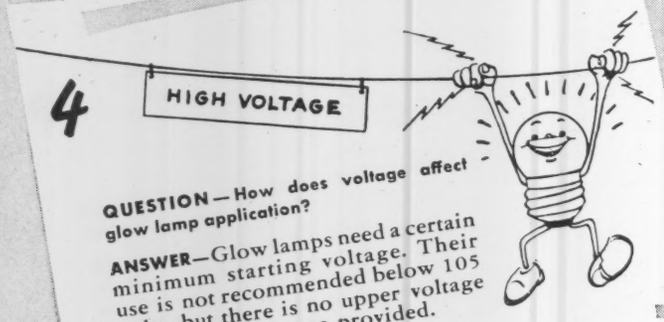
**ANSWER**—They're ideal as indicators. Such applications include annunciators, control panels, electrical appliances, testing devices, warning signals, pilot lights. Glow lamps also provide a source of low illumination for night lights, exit lights, dial lights, etc.

3

**QUESTION**—What are the main advantages of glow lamps from the product designer's standpoint?

**ANSWER**—(a) Distinctive orange-red glow—high visibility.
(b) Dependable performance and long life—rated at 3000 hours.
(c) Very low current consumption—as little as 1/25-watt.
(d) Low brightness, low heat.
(e) High resistance to shock and vibration.
(f) Can be installed in small space.
(g) Operate directly from regular 105-125, and 210-230 volt circuits, a-c or d-c.

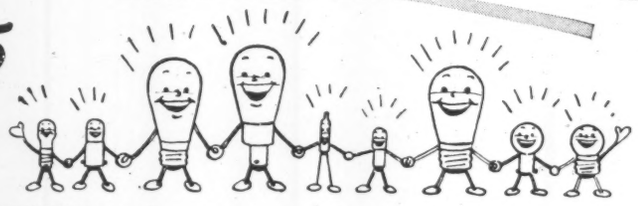
4




**QUESTION**—How does voltage affect glow lamp application?

**ANSWER**—Glow lamps need a certain minimum starting voltage. Their use is not recommended below 105 volts, but there is no upper voltage limit if resistors are provided.

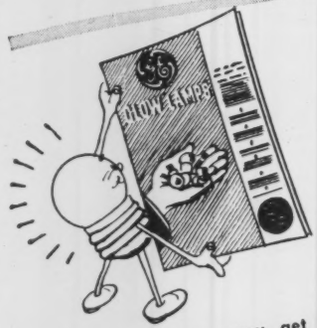
5



**QUESTION**—In what sizes are glow lamps made?

**ANSWER**—General Electric makes a complete line of neon glow lamps, in a wide variety of miniature bulb sizes, and in wattages from 3 watts to 1/25 watt, with both screw bases and bayonet bases.

6



**QUESTION**—Where can you get full information on G-E Neon Glow Lamps and their application to your product?

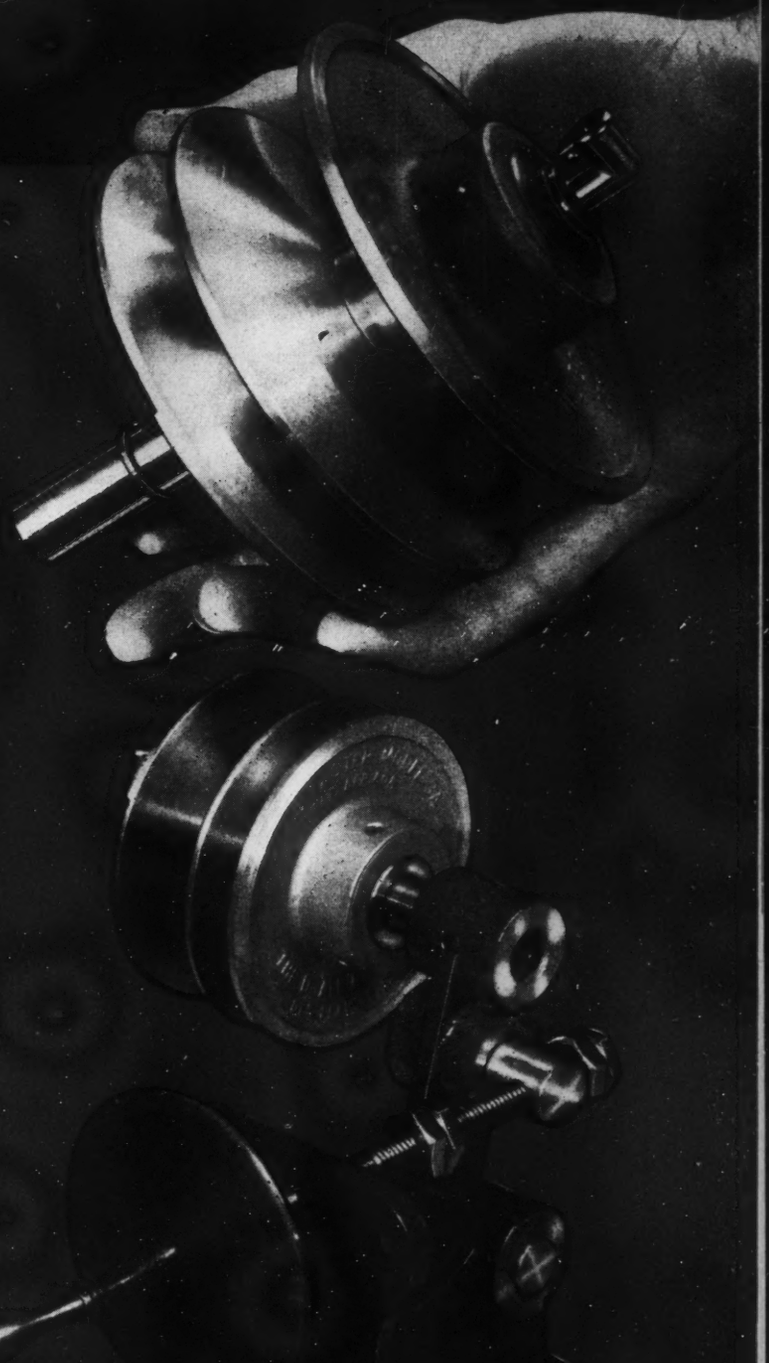
**ANSWER**—Write to Nela Specialty Division, Lamp Dept., General Electric Company, 1 Newark Street, Hoboken, N. J.

# G-E LAMPS

**GENERAL ELECTRIC**

*Nela Specialty Div. Lamp Dept., 1 Newark St., Hoboken, N. J.*

# IMPROVE YOUR PRODUCT with Trouble-Free VARIABLE SPEED



## SPEEDMASTER

***4 to 1 Ratio*** Rapid, gradual speed variations at finger-tip control. A thousand speeds ranging from one-half to twice that of direct hookup. For fractional h.p. drives.

***Self-Aligning*** Floating pulley assembly aligns V-belts automatically—prevents excessive belt wear.

***Durable*** Machined, wear-resisting pulleys of special aluminum alloy. Unit is lightweight, compact.

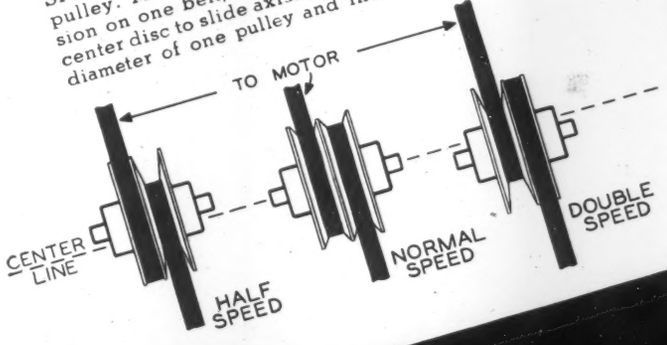
***Flexible*** Method of installation to suit machine design. Location and control method variable.

***Foolproof*** Simplified; trouble-free—only 2 rotating parts. Oil-impregnated bearings reduce oil care. Hub is shielded against dust.

*QUANTITY USERS: Write For* SPEEDMASTER *Engineering Service*

## HOW IT WORKS

SPEEDMASTER is belted to driving pulley and driven pulley. Moving it at right angles to axis increases tension on one belt, reduces that on the other. This causes center disc to slide axially which gradually reduces pitch diameter of one pulley and increases that of the other.




The DoALL Company

Reg. U.S. Pat. Off.

DoALL STORES IN KEY CITIES

DES PLAINES, ILLINOIS

# You Know

## THIS IS ONE PIECE OF METAL

# Do You Know

## WOLVERINE TRUFIN IS ALSO FORMED FROM ONE PIECE?

Aside from the advantage of providing increased surface area, Trufin—because of its integral fin construction—is capable of withstanding vibration—a factor of serious consideration in many heat transfer situations. Consequently, Trufin adapts itself to a wide range of applications.

In the fabrication of Trufin, the fins are formed of the metal squeezed out from the surface of the tubing; hence they remain an integral part of the tube itself.

Trufin is available in various fin spacings, fin heights and alloys to meet your specific needs.

We invite you to draw on the extensive experience and knowledge represented in the staff of our Customers' Engineering Department. We are anxious to help you with any problem that deals with heat transfer. Would you like a report on the correlation of data on transfer of heat through use of finned tube? Ask for a copy on your stationery.

**WHO'S WHO AMONG WOLVERINE REPRESENTATIVES**

**H. E. RIECKELMAN**
416 Jackson Bldg. MA 2072 Buffalo 2, New York

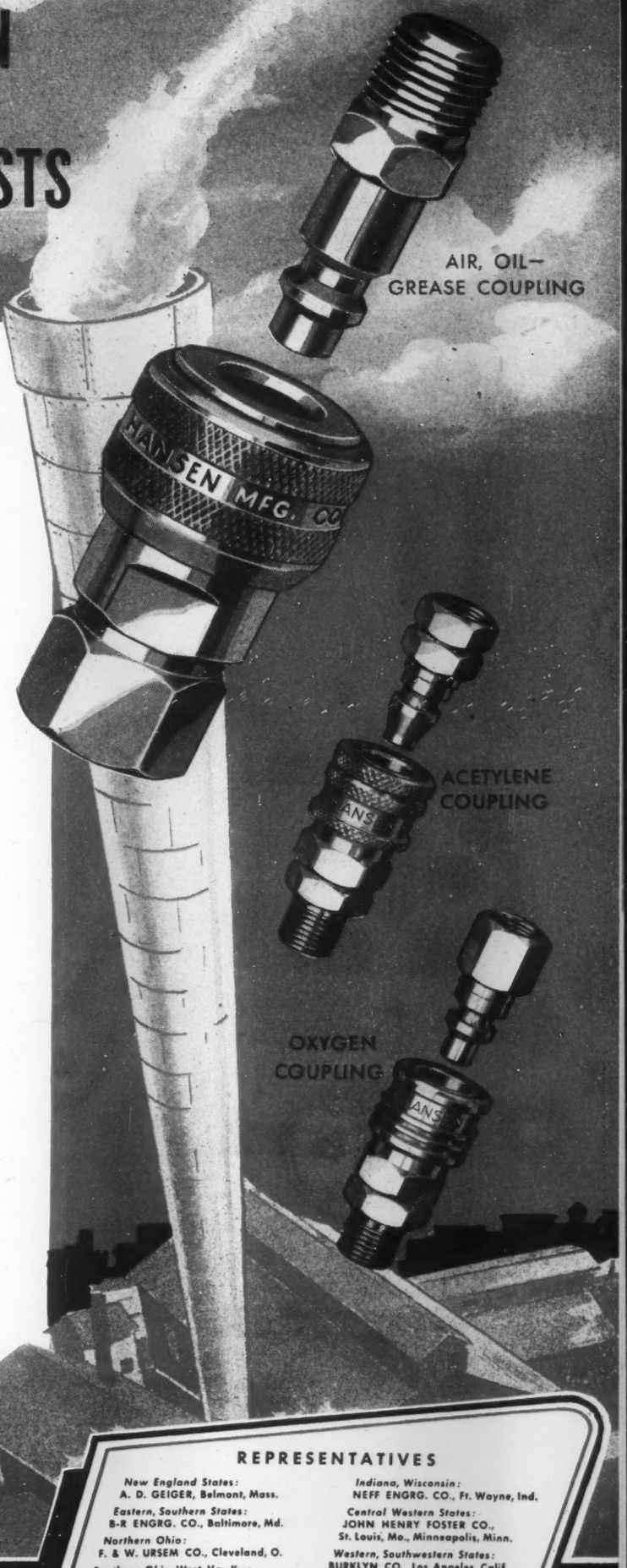
Represents Wolverine in the state of NEW YORK except the following counties: Sullivan, Ulster, Dutchess, Orange, Putnam, Rockland, Westchester, Bronx, New York, Kings, Queens, Nassau, Suffolk, and Richmond.

**WOLVERINE**
**TUBE DIVISION**

CALUMET & HECLA CONSOLIDATED COPPER COMPANY

1411 CENTRAL AVENUE • DETROIT 9, MICHIGAN
*In Canada: UNIFIN TUBE CO., LONDON, ONT.*

# INCREASED PRODUCTION
## IS ONE THING
# CUTTING PRODUCTION COSTS
## IS ANOTHER




# HANSEN
## COUPLINGS
## DO BOTH

Connections and change-overs become a matter of seconds when you use Hansen Couplings. That means time and money saved with no hold-up of costly operations.

Hansen couplings are toughly constructed for hard abuse, yet carefully and simply designed for finger-tip control. Merely insert plug in socket and coupling is connected; a slight pull on the sleeve and it is disconnected. No twisting or manipulating of parts, no leakage. Complete swivel action prevents kinking of hose. Made for air, oil, grease, oxygen and acetylene to handle pressures from ounces to 10,000 pounds.

*Write for folder describing*
*Hansen couplings for industrial uses.*

**REPRESENTATIVES**

*New England States:*
A. D. GEIGER, Belmont, Mass.

*Eastern, Southern States:*
B-R ENGRG. CO., Baltimore, Md.

*Northern Ohio:*
F. & W. URSEM CO., Cleveland, O.

*Southern Ohio, West Va., Ky.:*
STEINHAGEN AIRLINE PRODUCTS, Dayton, O.

*Northern Ill., Eastern Iowa:*
NORRIS ENGRG. CO., Chicago, Ill.

*Indiana, Wisconsin:*
NEFF ENGRG. CO., Ft. Wayne, Ind.

*Central Western States:*
JOHN HENRY FOSTER CO., St. Louis, Mo., Minneapolis, Minn.

*Western, Southwestern States:*
BURKLYN CO., Los Angeles, Calif.

*Northern Calif., Nevada:*
H. E. LINNEY CO., Oakland, Calif.

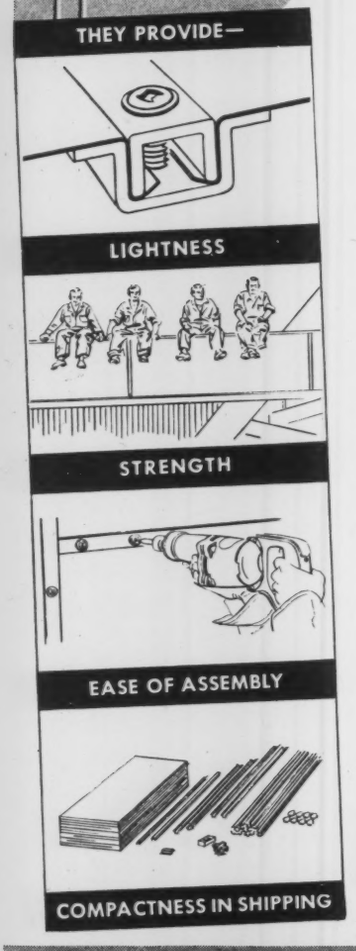
*Michigan:*
WM. H. NASH CO., Detroit, Mich.

**THE HANSEN MANUFACTURING CO.**

1786 EAST 27th STREET • CLEVELAND 14, OHIO

# *These are panels of*
# *LINDSAY STRUCTURE*

**Modern, Efficient method of assembly of light sheet metal**




## PUT THEM TOGETHER AND SOLVE YOUR "HOUSING PROBLEM"

For neatness, strength, lightweight, and ease of assembly, investigate this proved, easy method of building cabinets and housings, dryers, buildings, and many other types of structures.

Lindsay Structure assemblies can help you speed up your production of cabinets, housings, and truck bodies. With Lindsay Structure no tooling up is necessary—no special machinery is required. No riveting, no welding, no waste.

It's easy to order Lindsay Structure units. Specifications are developed and a complete assembly—panel sheets, framing members, fittings, all die-formed, die-cut, die-rolled to exact dimensions—is shipped to you knocked down and ready to be put together in your factory or on the spot anywhere.

Investigate this modern method of weight-saving construction in steel or aluminum. It can save you time and labor. Write to **The Lindsay Corporation, 1742-25th Ave., Melrose Park, Ill. Sales Offices: Chicago, New York, Atlanta, San Francisco, Montreal.**

LS
REG. U. S. PAT. OFF.

# LINDSAY STRUCTURE

U. S. Patents 2017629, 2263510, 2263511
U. S. and Foreign Patents and Patents Pending

**THE MODERN METHOD OF LIGHT METAL CONSTRUCTION**

# VIBRATION CONTROL *is part of design*

JUST as you have specialized in your type of product, so have we specialized in ours. With LORD Vibration Control Products we are cooperating with manufacturers to perfect smooth, quiet operation of their machines.

The best place to apply LORD Vibration Control to your product is on the drawing board; and the best time is when your designs are in the preliminary stage. During this stage, it is easy to select the points which are most advantageous for mounting applications. Space allotments, center-line locations and constructional features can be selected so that the inexpensive standard LORD Mountings may be installed easily when assembly begins.

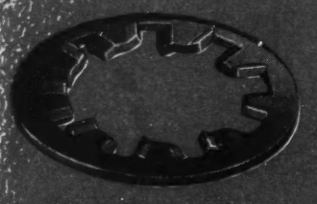
It is also during this stage that LORD Field Engineers can be of greatest service to you. By using their knowledge and experience in this specialized field, you literally place a trained Vibration Engineer upon your staff without cost. Just drop us a line, or notify our nearest Field Office, and a representative will call upon you. There is no obligation.

## LORD MANUFACTURING COMPANY, ERIE, PA.

FIELD OFFICES { New York, N.Y. Detroit, Mich. Washington, D. C. Chicago, Ill. Burbank, Cal.
Canadian Representative: Railway & Power Engineering Corp., Ltd., Toronto, Canada.

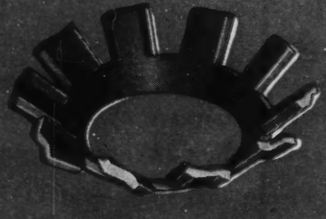
LORD
BONDED RUBBER
*Shear Type*
MOUNTINGS

# Ever LOCK WASHERS

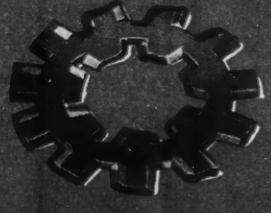


Standard Internal EverLOCK

Standard External EverLOCK



Standard 82° Countersunk EverLOCK



Standard Internal-External EverLOCK

## WIDE CHISEL EDGES *Checkmate* EVERY LOOSENING ACTION

EverLOCK Washers are designed to give *extra traction* needed when your assemblies are subjected to extreme strain, expansion, contraction or vibration.

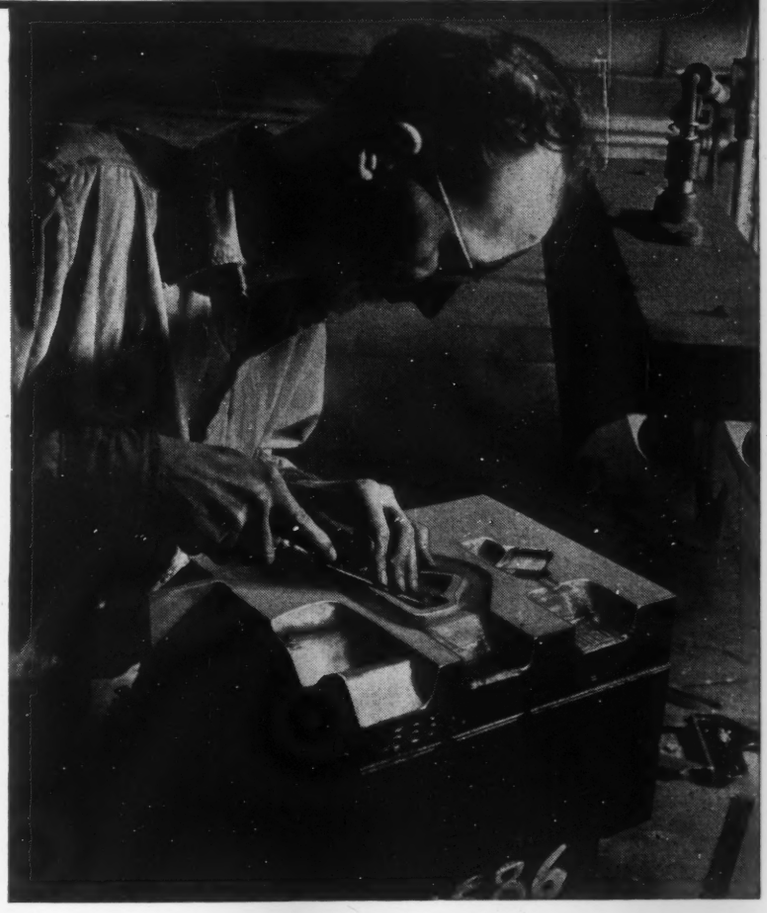
Many wide chisel edges . . . driven into the contiguous faces of both work and nut by powerful spring tension . . . grip with their *full* width to provide unmatched staying power.

Application is fast and easy. Four standard types meet most lock washer needs. Guard your assemblies with "The Washer That Has The Edge." Wire, phone or mail your orders today.

**THOMPSON-BREMER & CO., 1636 W. HUBBARD ST., CHICAGO 22, ILL.**

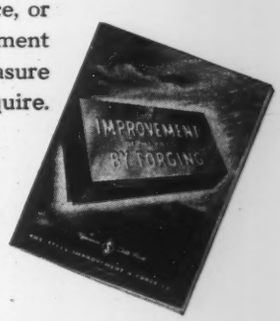
# THE VITAL ELEMENT *IN THE IMPROVEMENT OF METALS BY FORGING IS . . . Men!*

An irrepressible striving for perfection won lasting distinction for the skilled artisans of the Renaissance period. With their willing hands and devoted thought, common metals became objects of usefulness; objects that gave pride alike to their makers and to those who used them. With these proud craftsmen, quality was more than an obligation—it was a tradition. Today forging craftsmen, such as die makers, strive for perfection in sinking impressions for the forming of simple and complex designs to close tolerances. Thus, these men are demonstrating that the vital element in the improvement of metal by forging is . . . men!



● The quality, as well as the cost of a forging, is determined by its design, the material of which it is made, and the production techniques required to form it. *The primary object in forming a part is to develop fully the metal* quality required to meet a specific service condition. Unvarying quality and lowest cost at the point of assembly are usually obtained by employing forging techniques that achieve a high rate of production with minimum scrap loss, and subsequent reductions in the cost of machining and finishing.

Fortified by over 33 years of experience in forging intricate designs, and by specialized metallurgical and engineering skill thus acquired, Steel Improvement Forging Engineers and Metallurgists: (1) know the exact forging technique that should be utilized for developing fully the qualities, inherent in a specific grade of steel, that are required to meet the stresses occurring in a specific service condition; (2) advise and assist designers regarding the correct placement of parting lines and other design elements; and (3) adhere strictly to a policy of projecting a promise of quality and delivery only when such promise can be substantiated by fact or experience, or both. Consult a Steel Improvement Forging Engineer about the measure of quality in forgings you require.




*Write for reference booklet titled "The Improvement of Metals by Forging", which has been prepared especially for executive engineers, designers and metallurgists.*

DROP
**THE STEEL IMPROVEMENT & FORGE CO.**
FORGINGS

954 East 64th Street CLEVELAND, OHIO

*SALES OFFICES:* NEW YORK • CHICAGO • MILWAUKEE • TULSA • LOS ANGELES

*DROP, UPSET AND PRESS FORGINGS FROM A FEW OUNCES TO 500 LBS. OF ALL FORGEABLE METALS*

Here's the new and improved *orange-colored* Wrap-Rax, a synthetic resin in easy-to-use tape form for insulating plating racks. It is also effectively used as a stop-off in hard chromium and other plating solutions.

Check these advantages which mean savings for you:

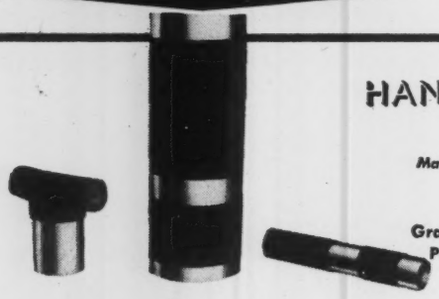
**ADHESIVE**—quick and easy to apply.

**DURABLE**—tough plastic, resists abrasion and wear. Chemically resists all cleaning, pickling and plating solutions commonly used.

**UNIFORM COVERAGE**—edges and flat surfaces covered equally.

**CLEAN and SAFE**—as easy to use as friction tape, no dripping liquids, toxic or inflammable fumes.

## AN EFFECTIVE STOP-OFF, TOO



Use Wrap-Rax and prevent disintegration of your plating racks—cut current and metal losses to a minimum. Wrap-Rax is furnished in 250-ft. rolls, ¾" width, and can be used on old racks as well as new.

HANSON-VAN WINKLE-MUNNING · MATAWAN, NEW JERSEY, U.S.A. · SINCE 1820

2442

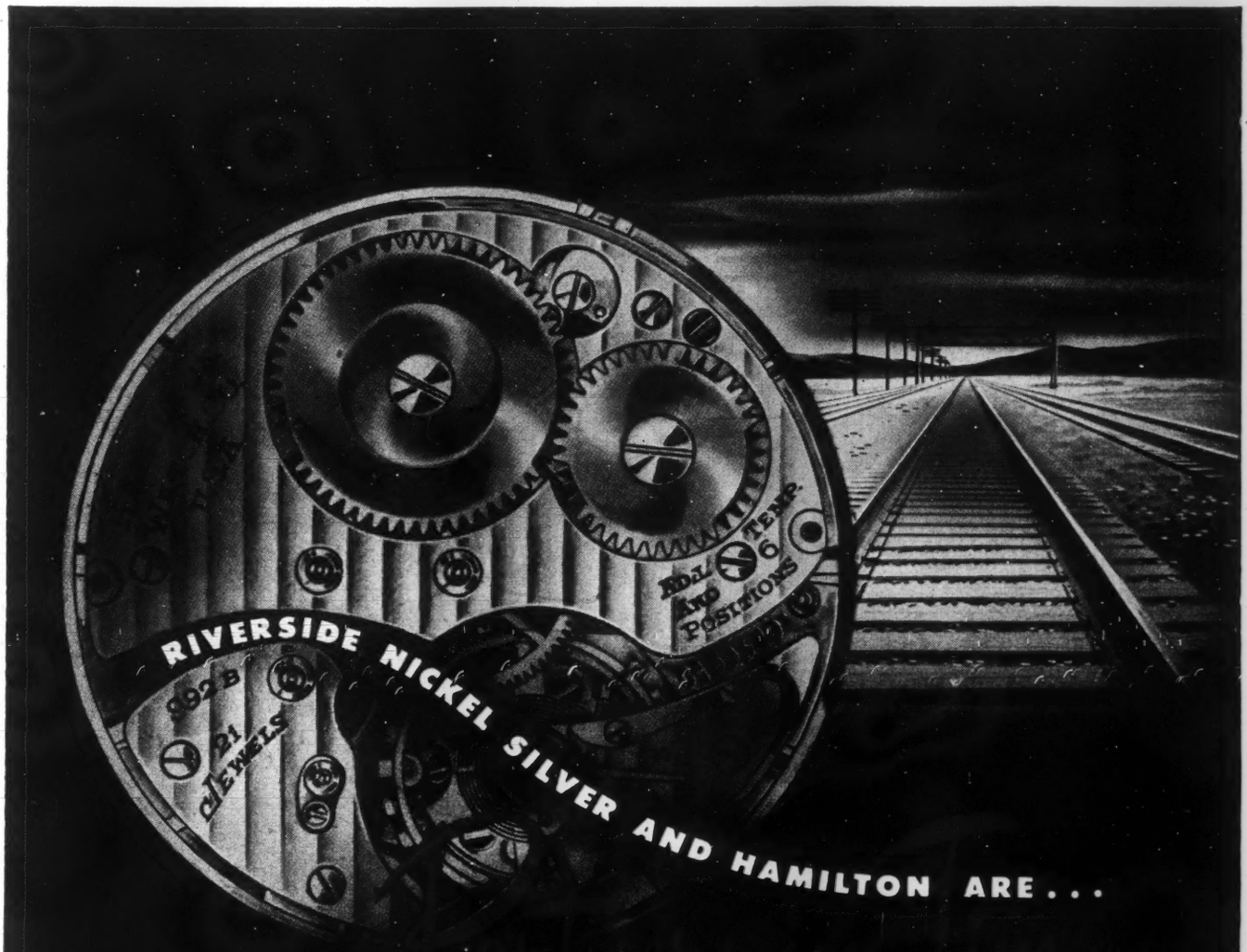
## HANSON-VAN WINKLE-MUNNING COMPANY

MATAWAN, NEW JERSEY

*Manufacturers of a complete line of electroplating and polishing equipment and supplies*

*Plants:* Matawan, New Jersey • Anderson, Indiana

*Sales Offices:* Anderson • Chicago • Cleveland • Dayton • Detroit
Grand Rapids • Matawan • Milwaukee • New Haven • New York • Philadelphia
Pittsburgh • Rochester • Springfield (Mass.) • Stratford (Conn.) • Syracuse




*Hamilton Movement Used in Railway Special Watches*

For more than 55 years the Hamilton Watch Company has turned out railroad, navigation and personal timepieces of meticulous accuracy. And the makers of the famous "Watch of Railroad Accuracy" have long been a customer of Riverside.

Plates and bridges in the movements of Hamilton Watches are Riverside *Nickel Silver* . . . for three important reasons: 1. Riverside *Nickel Silver*, though tough, is easy to machine in any manner, providing great strength in tapped holes. It is highly resistant to wear, fatigue and corrosion. 2. It is easily worked and gives utmost satisfaction in fabrication and performance. 3. Riverside *Nickel Silver* is silvery white clear through. It takes a high polish or a fine damaskeen-type finish.

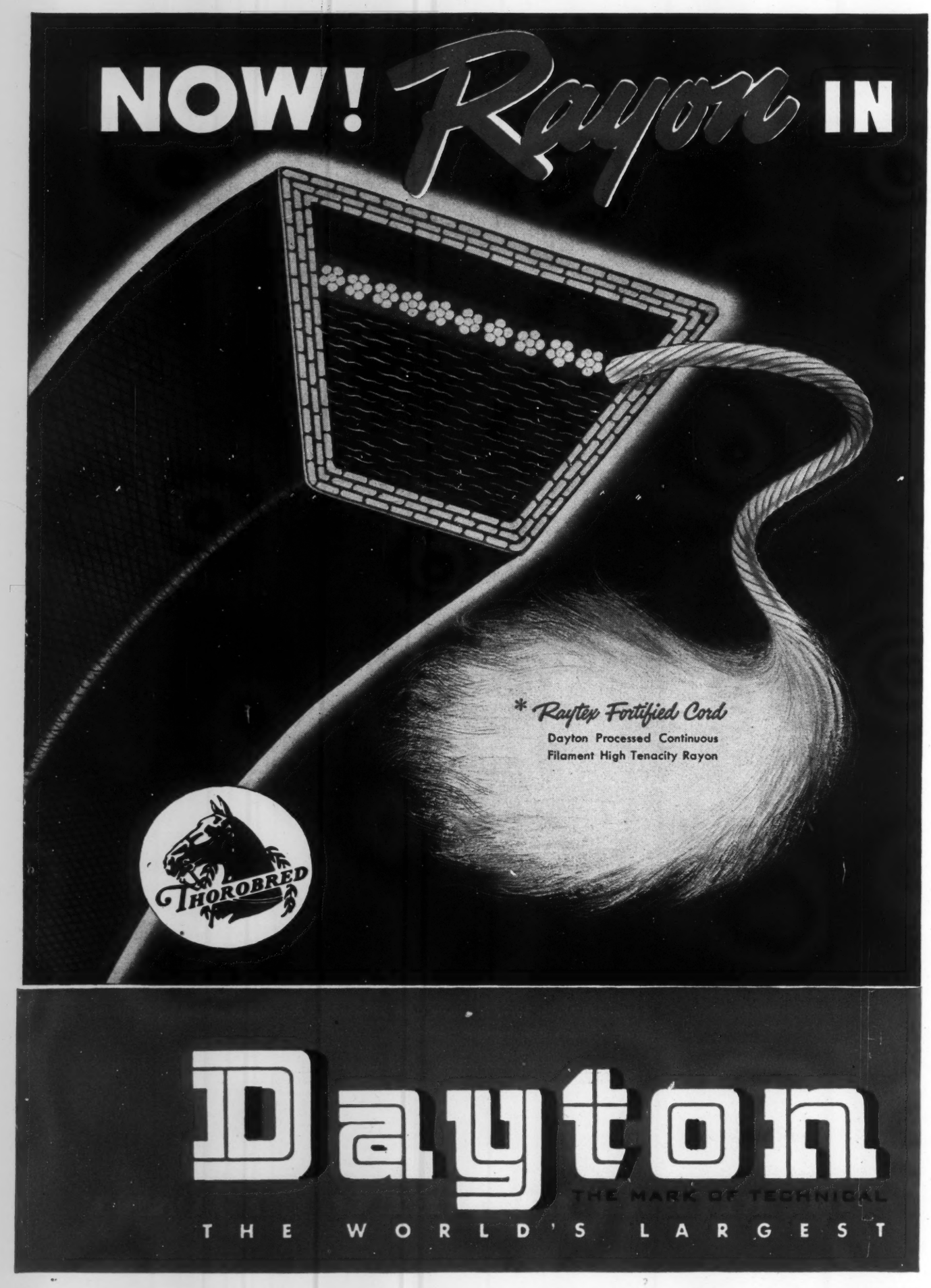
Riverside *Nickel Silver* is widely used whenever a combination of beauty, durability and economy is essential in a metal.

*For more information and interesting catalogs about Riverside* Nickel Silver *and Riverside's two other alloys,* Phosphor Bronze *and* Beryllium Copper, *write today.*

**INSIDE RIVERSIDE**

Our wide-spread reputation as specialists in the non-ferrous industry is, we believe, a direct reflection of our painstaking research and care in treating each problem individually. Box score to date: Production of 50 distinct alloys for customers' individual requirements.

# THE RIVERSIDE METAL COMPANY


NOW! Rayon IN
* Raytex Fortified Cord
Dayton Processed Continuous
Filament High Tenacity Rayon
THOROBRED
Dayton
THE MARK OF TECHNICAL
THE WORLD'S LARGEST

# DAYTON *Thorobred* V-BELTS

- MINIMIZES BELT STRETCH
- INCREASES FLEX STRENGTH
- INCREASES V-BELT LIFE

### MINIMIZES V-BELT STRETCH

Low stretch, high tenacity *Raytex Fortified Rayon Cord, used in the neutral or strength section of Dayton V-Belts, is manufactured in continuous filaments . . . then twisted together to form cable-like cord, just as steel wires are twisted together to make a steel cable. That's why Raytex Fortified Rayon Cords practically eliminate stretch in the new Dayton Thorobred . . . which means fewer take-ups and less maintenance with every belt pulling its share of the load.

### INCREASES FLEX STRENGTH

Because Rayon Cords are made of continuous filament, high tenacity Rayon, they combine high strength with greatest flexibility. This enables Dayton Thorobred V-Belts to flow smoothly around pulleys while transmitting power at maximum efficiency.

### INCREASES V-BELT LIFE

Because Rayon Cords have greater strength in small diameters, Dayton Belt Engineers are now able to build a more compact, thinner neutral section of maximum pulling power. Thus, bending stresses are minimized which, in turn, lengthens the life of Dayton Thorobreds.

The new Dayton Thorobred V-Belts built with *Raytex Fortified Rayon Cord are now in production . . . will be available soon in all sizes. Write for free sample of this new cord and descriptive booklet.

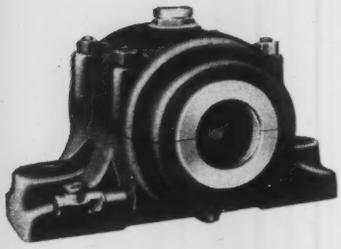
**DAYTON RUBBER • DAYTON, OHIO**

**Branch Offices: Atlanta • Boston • Chicago • Cincinnati Cleveland • Dallas • Dayton • Detroit • Los Angeles Minneapolis • New York • Philadelphia • St. Louis**

# Rubber

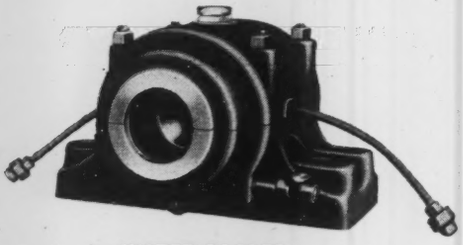
EXCELLENCE IN NATURAL AND SYNTHETIC RUBBER

MANUFACTURER OF V-BELTS



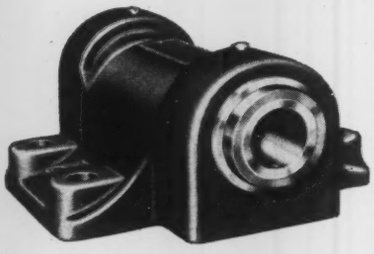
**SLEEVOIL PILLOW BLOCK**

A precision-built, ring-oiling babbitted bearing, self-aligning and exceptionally quiet. Special seals prevent oil leakage and keep dirt out. Field-proved by thousands of installations.



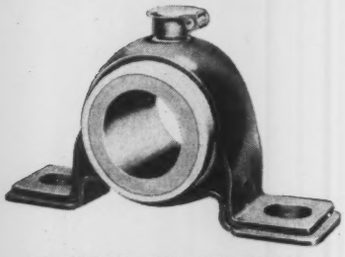
**WATER-COOLED SLEEVOIL PILLOW BLOCK**

Designed for applications where higher temperatures are encountered. Shaft sizes from 1-11/16" to 8". Widely used under industry's toughest operating conditions.



**DH BALL BEARING FAN AND BLOWER PILLOW BLOCK**

Single row, deep groove ball bearings for No. 2 arrangement. Inner race extended to form sleeve which carries shaft. Piston ring seals retain lubricant, exclude dirt. Shaft sizes 15/16" to 2-1/4". A favorite where compactness is at a premium.



**BRONZOIL PILLOW BLOCK**

Capillary bronze bushing has capacity of one-third its volume in oil. Reservoir with close fitting wick around bushing provides ample lubrication. Oil resistant and static proof grommets available for noise isolation. Sizes 1/2" to 1-1/4". America's standard for light applications.

Copyright, 1947, Dodge Mfg. Corp.

# FAN AND BLOWER BEARINGS

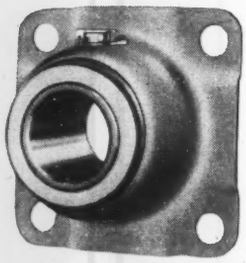
## *America's Most Complete Line*

Working closely with air conditioning equipment manufacturers, Dodge of Mishawaka has developed bearings to meet the exacting operating conditions encountered in this industry. Cost-saving products for the mechanical transmission of power are manufactured by Dodge for use in all industries.

**DODGE MANUFACTURING CORPORATION • MISHAWAKA, INDIANA**

**DODGE**

*of Mishawaka, Ind.*



**BRONZOIL FLANGED BEARING**

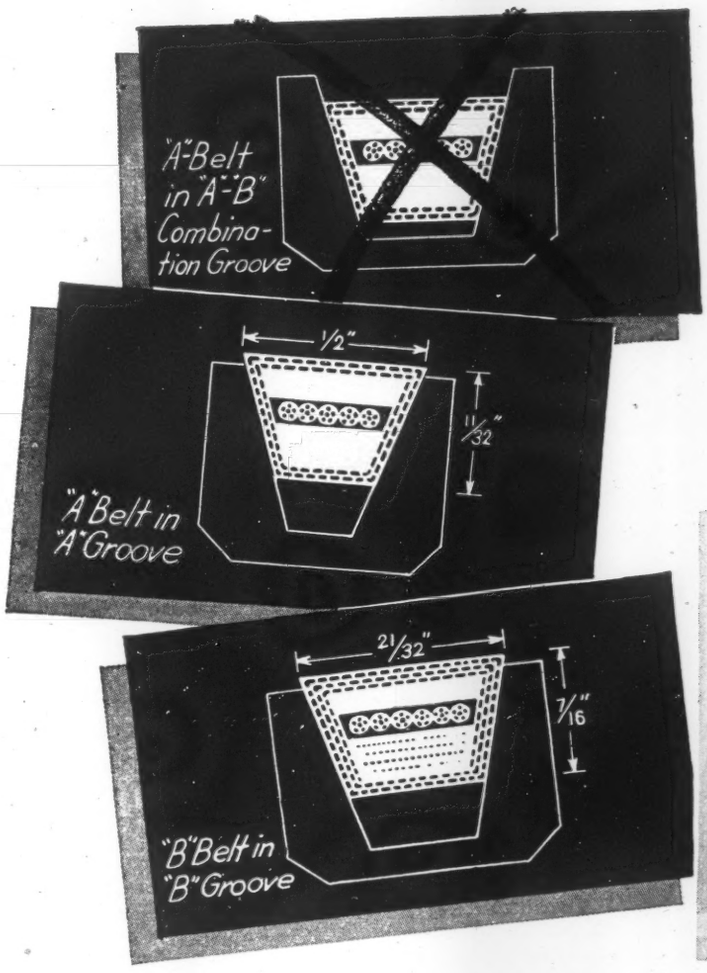
Mounted in heavy gauge steel flanged housing this bearing has the basic Bronzoil construction and characteristics as described at the left. Sizes 1/2" to 1-1/4". A proven performer in a new mounting.

***CALL THE TRANSMISSIONEER***

your local Dodge distributor, for information about the line of Dodge bearings for fan and blower service—and for news about Dodge products to cut costs and increase production in all industries. Look for his name under "Power Transmission Equipment" in your classified phone directory.

NAME PLATES

FOR YOUR NAME PLATE REQUIREMENTS, WRITE OUR SUBSIDIARY, ETCHING COMPANY OF AMERICA, 1520 MONTANA STREET, CHICAGO 14, ILLINOIS




# NOW...

# "A" and "B" V-Belts Fit Right and Show It

*. . . because Worthington Makes QD Sheaves with "A" or "B" Grooves . . . NOT a Combination!*

Never again will you have to compromise on sheaves with an "A–B" Groove combination. That's because Worthington now makes the Original QD Sheaves with "A" grooves for "A" Belts . . . "B" Grooves for "B" Belts. This progressive step was taken because Worthington found that more and more customers preferred this better-engineered drive . . . this better-fitting drive . . . this better-looking drive. Stocks include all sizes from 3" to 22" diameter in "A" . . . from 4" to 38" in "B".

### BETTER SERVICE FROM BIGGER STOCKS

Because of the steadily increasing demand for stock QD Sheaves, Worthington has installed new production facilities.

This stepped-up output has resulted not only in a 40% price reduction in "A" and "B" sizes but also in greatly improved service. From 18 stock Hubs and 791 stock Rims, Worthington customers can choose more than 25,000 stock QD Sheaves combinations for V-Belt applications ranging from ½ to 200 hp — plus smaller fractional horsepower sizes . . . all stocked at strategic points throughout the country.

### "Strongest Sheave for Its Weight Ever Made"

Investigate the reasons why customers agree that the new Worthington QD Driven Sheaves are the strongest sheaves for their weight ever made: "I" Beam construction of spokes; taper-mated, load-tested Hubs and Rims; full-sized Pull-Up Bolts; a design that reduces overhang stresses. These and many other features that prove *there's more worth in Worthington* are described in Bulletin VI400-B7. Ask your nearby Worthington distributor for it. *Worthington Pump and Machinery Corporation, Merchandising Division, Harrison, N. J. 36 District Offices throughout the U. S.*

**WORTHINGTON QD SHEAVES**

Easy to get on . . . Easy to get off . . .
Yet always tight on the shaft

**WORTHINGTON**

B6-53

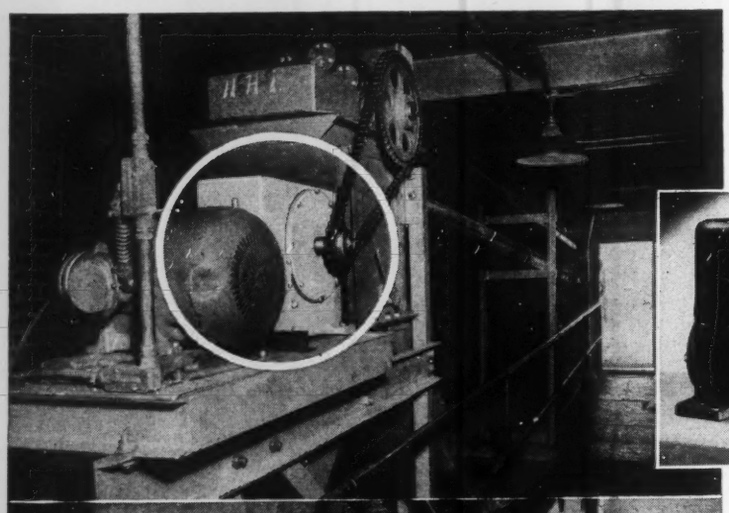
**PRODUCTS BASED ON MARKET RESEARCH**

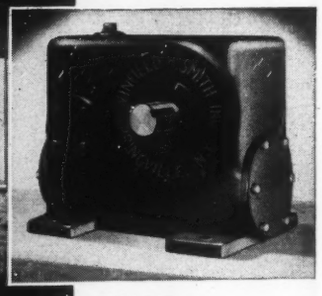
Centrifugal Pumps | Rotary Pumps | Steam and Power Pumps | Vertical and Horizontal Compressors | Multi-V-Drives | Variable Speed Drives

# FLEXIBILITY... *Yes!* DURABILITY... *of Course!* DEPENDABILITY... *Always!*

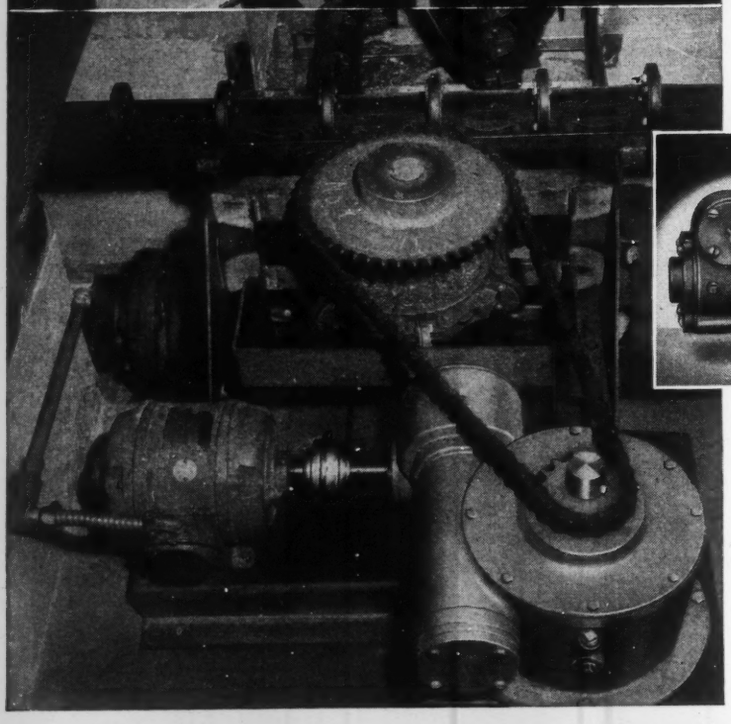
WHS

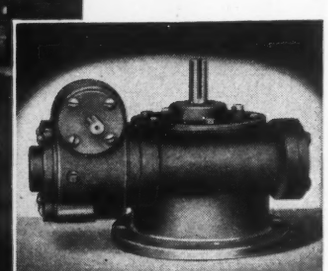
*Speed Reducers*





No. 8DB





No. 8BDV

**This Mile-Long Chip Conveyor System at PACKARD MOTOR CAR CO. plant, incorporates in its design the dependable performance of WHS Worm Gear Speed Reducers. The system was constructed by Hapman Conveyors, Inc., Detroit.**

Here is flexibility of a high order . . . a conveyor that collects virtually all steel chips from 181 machines in Packard departments machining cylinder blocks, cylinder heads and exhaust manifolds for Clipper models. Physical handling of chips is practically eliminated.

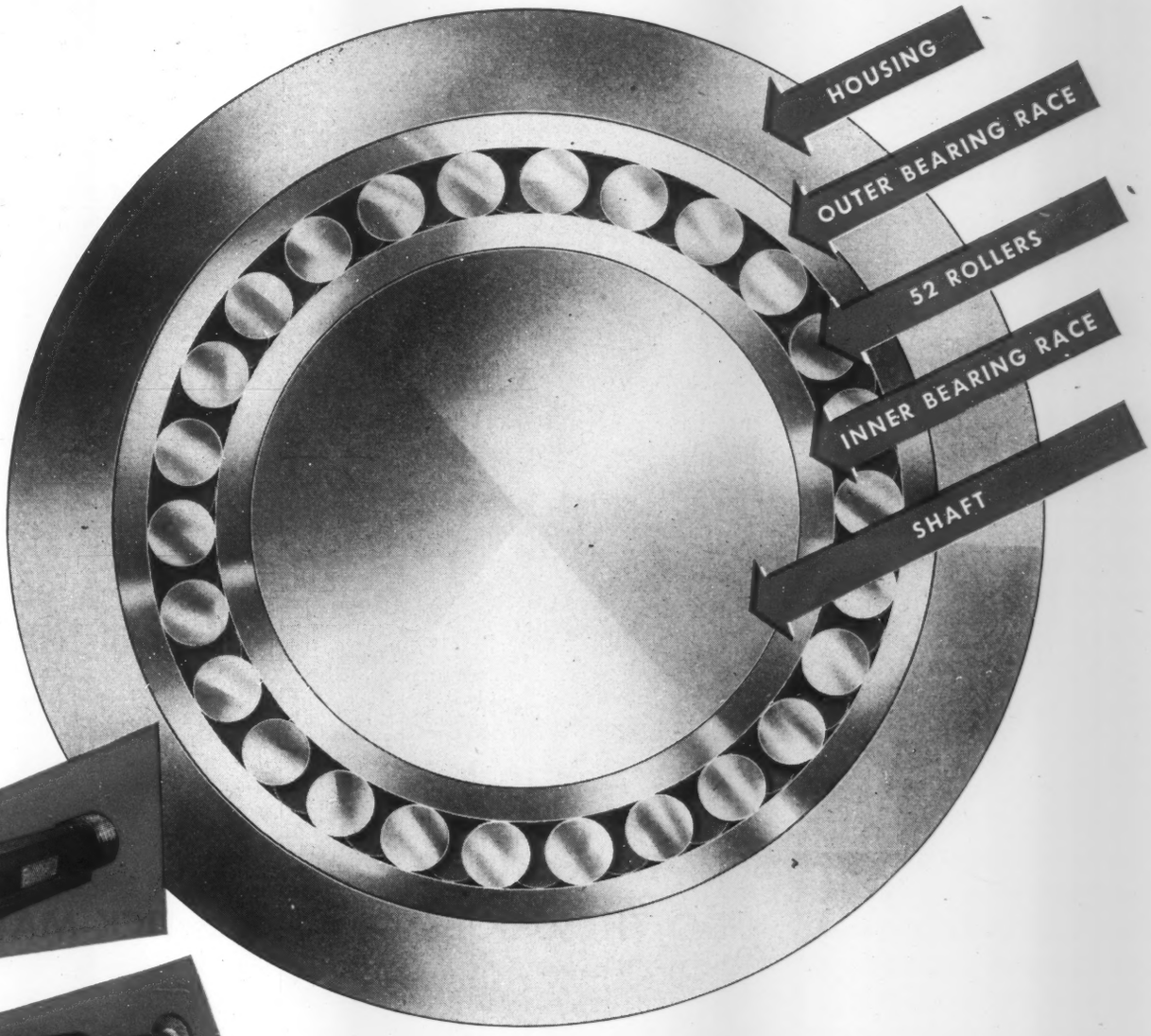
Eleven 1 H.P. and four 3 H.P. motors supply the power . . . and an integral part of the power transmission system are the WHS Speed Reducers. The upper photograph shows a stock model No. 8DB, ratio 225-1, at the end of the chip conveyor line. The lower photograph shows a stock model No. 8BDV, ratio 660-1, installed in a cross conveyor drive.

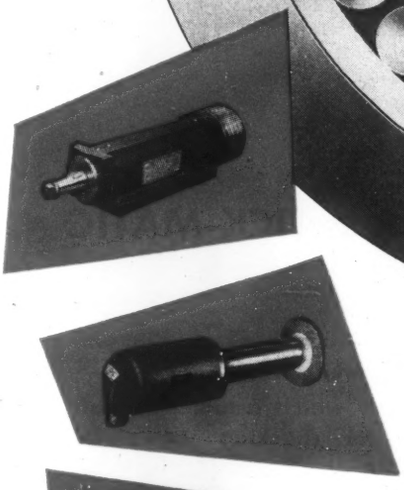
There is a type and size of WHS Speed Reducer for practically every modern industrial requirement . . . "The most complete line of speed reducers available from any one source". All are shown in our pocket size Catalog 145 . . . a copy free on request.

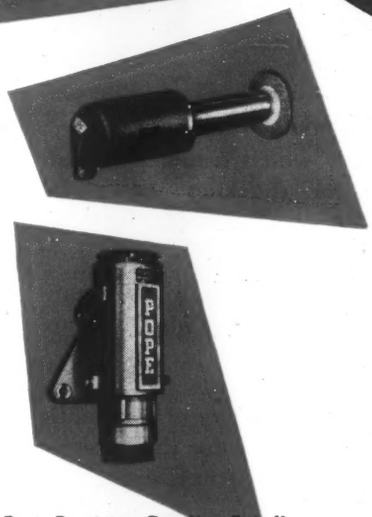
MEMBER OF AGMA

**WINFIELD H. SMITH CORPORATION**

16 ELTON STREET . . . SPRINGVILLE . . . ERIE COUNTY . . . NEW YORK








Pope Precision Grinding Spindles like these are equipped with double row roller bearings of enormous excess capacity, as shown above. Each bearing is given the exact radial preload to assure best grinding finishes and long life.

## *SEE FOR YOURSELF*

### *Why* POPE PRECISION SPINDLES *have* AMPLE ABILITY *to stand up under hard work*

Note the practically CONTINUOUS BEARING SUPPORT for the shaft provided by the SKF Double Row Roller Bearing. This insures the smooth running necessary for FINE FINISHES on ground surfaces.

And remember — these are ROLLERS you are looking at. For *rugged ability* to *carry loads easily* and *smoothly* for *long periods, there's nothing like a roller.*

No. 39

**POPE**

**POPE MACHINERY CORPORATION**

ESTABLISHED 1920

261 RIVER STREET • HAVERHILL, MASSACHUSETTS

BUILDERS OF PRECISION SPINDLES

**SNAP-LOCK** TRADE MARK

# LIMIT SWITCHES DO THESE JOBS ON THE CHUCK-MATIC

The new Acme-Gridley Chuck-matic single spindle machine is making exceptional records in heavy-duty, high production machining of castings and forgings up to 12″.

Its accuracy and its split-second timing are controlled by Namco Snap-Lock Limit Switches—the one limit switch made for machine tool builders by machine tool builders.

***On the Chuck-Matic, Snap-Locks do these jobs:***

1. **Control stopping mechanism for work spindle.**
2. **Provide safety—to lock chuck opening and closing during working cycle.**
3. **Operate solenoid which actuates the air control valve for chucking workpiece.**
4. **Control solenoid operated valve to start and stop slide feed mechanism.**

Of course it is only natural for us to use Snap-Locks on our own machines—that's what they are designed and built for.

But it is a fact that Snap-Locks are used by more than 80% of all the builders of automatic machine tools. There is a reason for that, too—a reason explained in detail in Bulletin EM-42. Send for your copy.

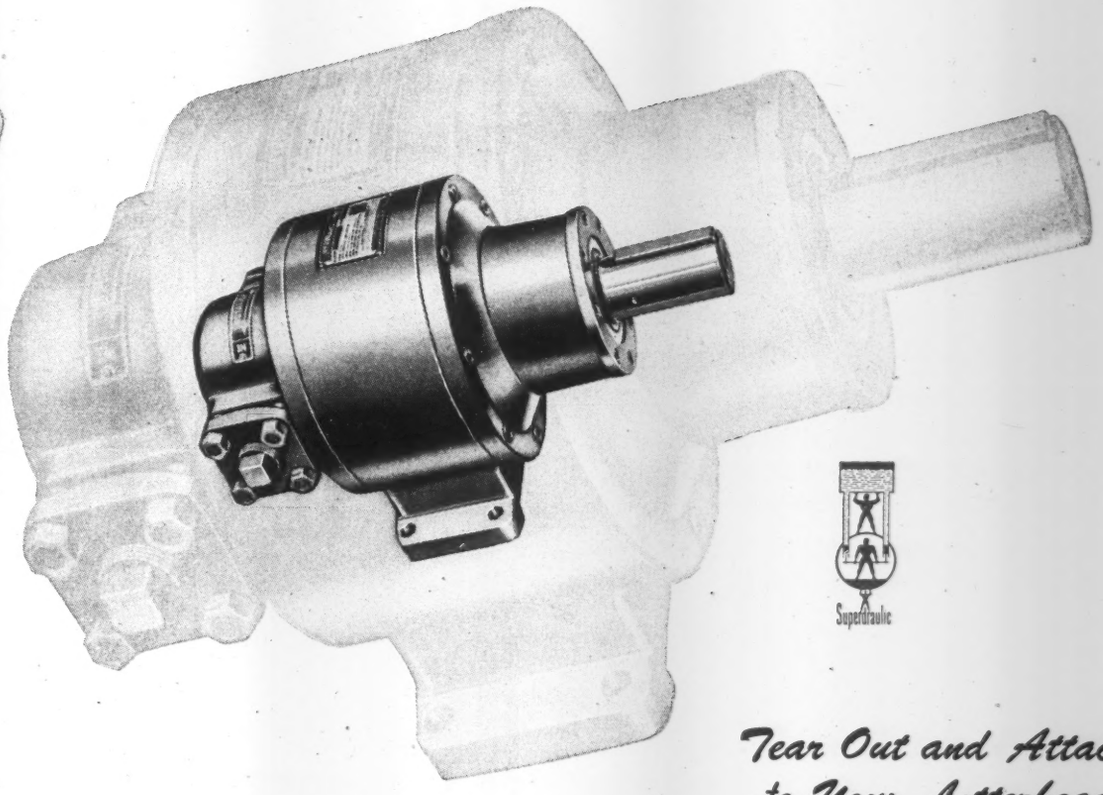
ELECTRICAL MANUFACTURING DIVISION

## The NATIONAL ACME CO.

170 EAST 131st STREET • CLEVELAND 8, OHIO

**Acme-Gridley Bar and Chucking Automatics: 1-4-6 and 8 Spindle • Hydraulic Thread Rolling Machines • Automatic Threading Dies and Taps • The Chronolog-Limit, Motor Starter and Control Station Switches • Solenoids Centrifuges • Contract Manufacturing**

# *Junior does a Man-Size Job!*




HYDRAULIC BALANCE FOR LIFE

HYDRAULIC BALANCE FOR LIFE

**Only 6" in Diameter • Length 11"**
**Weighs Only 35 Lbs • Delivers 5000 psi**

Here's the ideal pump for the many applications where high pressures must be produced from a unit of minimum size and weight.

As its name implies, Superdraulic Junior is practically a duplicate (on a reduced scale) of the famous Superdraulic 40 Horsepower Constant Delivery Pump. It delivers 5000 psi in continuous duty service, with volumes of 3 gpm at 1800 rpm, or 2 gpm at 1200 rpm. Volumetric efficiency averages 95% with the lightest hydraulic oils. Radial multi-plunger design insures smooth delivery. Perfect hydraulic balance insures thousands of hours of trouble-free service. Superdraulic Junior can also be used as a powerful reversible hydraulic motor.

*Only Superdraulic Junior Pumps Can Give You All This!*

# Superdraulic Corporation

HYDRAULIC PUMPS • MOTORS • TRANSMISSIONS • VALVES

MILLER AT FORD ROAD • DEARBORN, MICHIGAN

*Tear Out and Attach to Your Letterhead*

**What do You Want In a Small Constant Delivery Pump?**

- ☐ Up to 5000 pounds per square inch pressure for continuous duty service.
- ☐ 3 Gallons per minute at 1800 rpm. Or 2 gpm at 1200 rpm.
- ☐ Small size. 6 inches in diameter—11 inches long—Weight 35 pounds.
- ☐ *Perfect* hydraulic balance. Thousands of hours of trouble-free service.
- ☐ High volumetric efficiency: 95% with the lightest hydraulic oils.
- ☐ Radial multi-plunger design. Smooth delivery.
- ☐ Efficient performance as a powerful reversible hydraulic motor.
- ☐ Quantity production prices.

***Complete information upon request. Just check ☒ your requirements.***

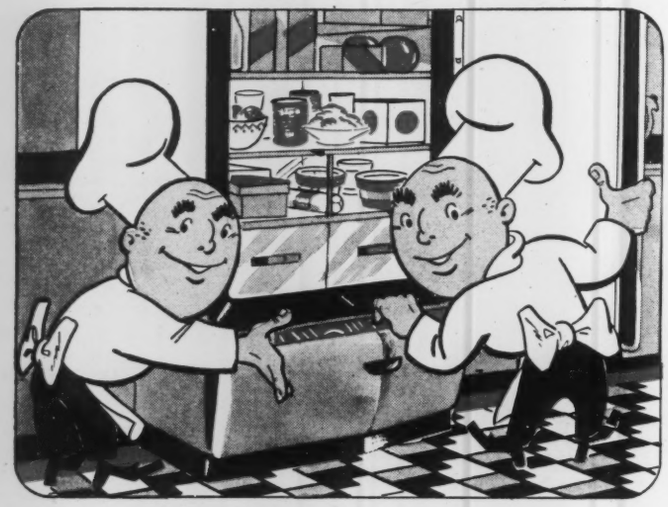
HYDRAULIC BALANCE FOR LIFE

HYDRAULIC BALANCE FOR LIFE

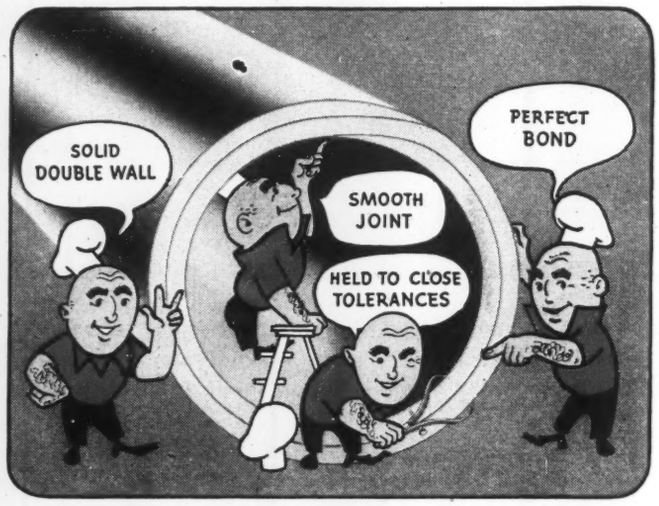
# How to bait a man trap

**1. BAIT FOR** a mantrap can be a luscious ice box cake, topped with frothy whipped cream, a crisp, fresh salad or a cold bottle of beer. Whatever suits a man's fancy best is his wife's sure way to anything from a trip to the movies to a new fur coat. But she can't set the snare by herself.

**2. MILADY'S** silent helper is her modern refrigerator. With its temperature regulator, rapid ice cube maker, frozen food compartment and a dozen other gadgets, it gives free play to her culinary talents. But refrigerators weren't always as dependable as those that grace kitchens of today.



**3. BUNDYWELD** Tubing in condenser coils, compressor lines and connecting tubes helped bring new dependability to refrigerators. And Bundyweld's hundreds of other uses include carrying fuel, oil, lubricants, vacuums and hydraulic fluids in motor vehicles and gas in modern ranges.




**4. BUNDYWELD** is different from other tubing. A single strip of basic metal, coated with a bonding alloy, is rolled continuously twice laterally into tubular form, then metallurgically bonded by intense heat—carefully controlled—to form a solid, double wall tube, held to close dimensions.

**5. SPECIFY BUNDYWELD!** That's the recommendation today from an army of engineers and product designers who recognize the advantages of this unique, superior tubing. Let Bundy Research and Engineering Departments illustrate the advantages of Bundy Tubing for your product. Available in steel, Monel and nickel. Write: *Bundy Tubing Company, Detroit 14, Michigan.*

**BUNDY TUBING**

★ ★ ENGINEERED TO YOUR EXPECTATIONS ★ ★

BUNDY TUBING DISTRIBUTORS AND REPRESENTATIVES:

| | | | | | |
|---|---|---|---|---|---|
| Pacific Metals Co., Ltd.<br>3100 19th St.<br>San Francisco 10, Calif. | Standard Tube Sales Corp.<br>1 Admiral Ave.<br>Maspeth, N.Y.C., N.Y. | Lapham-Hickey Co.<br>3333 W. 47th Place<br>Chicago 32, Illinois | Rutan & Co.<br>404 Architects Bldg.<br>Phila. 3, Pa. | Eagle Metals Co.<br>3628 E. Marginal Way<br>Seattle 4, Wash. | Alloy Metal Sales Ltd.<br>861 Bay St.<br>Toronto 5, Canada |

# Modern Machines Deserve MORSE PRODUCTS

Throughout industry, machinery and equipment manufacturers find MORSE ROLLER and SILENT CHAIN DRIVES, FLEXIBLE COUPLINGS, FREE WHEELING, INDEXING and FRICTION CLUTCHES *the answer to mechanical power transmission problems.*

**MORSE CHAIN COMPANY • Detroit 8, Michigan • Ithaca, N.Y.**

A PRODUCT OF BW BORG-WARNER

# MORSE

MECHANICAL POWER TRANSMISSION PRODUCTS

# Topics

PRODUCTION DELAYS, necessitated by heat treating various aluminum alloys for different time periods, have been eliminated at the Glenn L. Martin Co. Four alloys, 53S, Alclad 14S, R-301 and 61S, are all aged together at 350 F for eight hours or 340 F for ten hours under the new method, saving 40 hours of furnace time each week.

EXPLOSION-PROOF electrical equipment will be used extensively on aircraft for the first time in the Republic "Rainbow", the world's fastest passenger transport plane.

GASKETS OF TEFLON, a tetrafluoroethylene resin, on lines carrying nitrating acids have given service life of at least one year. In every case failure was mechanical rather than chemical. Gaskets of other materials last one to two weeks in this service.

NATIONAL ELECTRICAL CODE, 1947 edition, is presented for the first time in conveniently bound reference size, uniform with the other four volumes of the National Fire Code published by the National Fire Protection Assn.

FROZEN MERCURY is being used successfully for expendable patterns in the production of investment castings. The mercury is solidified at — 40 F to the shape desired, sprayed with silica and invested in the mold. The mercury is melted out at room temperature for reuse.

PHENOLIC MOLDING COMPOUNDS were produced at the annual rate of 151,000,000 pounds during the first six months of 1946, an increase of 32,000,000 pounds over the previous six months.

ULTRASONIC TESTER, designed to indicate the presence of voids, cracks, porosity, laminations, poor bonds, and other flaws in metals, plastics and ceramics, has been developed by General Electric. The instrument consists of a transmitting-receiving system having a high-frequency generator, a crystal transducer for producing ultrasonic vibrations, a satisfactory medium such as water to transmit these vibrations, a second crystal transducer to convert the received mechanical energy into electrical signals, and an indicator supplying information for inspection.

TO CONDUCT RESEARCH in all phases of atomic power development the Atomic Energy Commission is starting construction of the Knolls Atomic Power Laboratory near Schenectady, N. Y. One building will house an experimental pile, another a 3½-million volt electrostatic, or Van de Graaff, generator. Other buildings of the group, which will be operated by General Electric Co. for the government, will be devoted to offices, metallurgy, chemical engineering and chemistry.

ICE HAS LESS TENDENCY to stick to silicone rubber than to other rubber stocks, as shown by preliminary tests by General Electric Co. This characteristic and the excellent heat resistance of silicones to hot dry air suggests its use in de-icing equipment on planes.

FOUR METALLIC PLIES in heavy-duty tires are equivalent in strength and durability to approximately twenty fabric plies commonly used. Although more rubber is used for one stranded-wire ply than for fabric, overall savings in rubber are effected. The metal sheath is resistant to punctures, bruises and blowouts, has greater resiliency, reduces creation of heat, and eliminates casing stretch.

ATOMIC ENERGY PAPERS, prepared by individual scientists who have worked or are working on the atomic project have been declassified. Comprising 270 papers they cover a wide variety of technical discoveries in mathematical, physical, chemical, engineering, and medical fields, according to the Office of Technical Service, Department of Commerce.

AGRICULTURAL TRACTORS & IMPLEMENTS • INDUSTRIAL MACHINERY • MATERIALS HANDLING EQUIPMENT • ROAD CONSTRUCTION & MAINTENANCE VEHICLES

*a NEW product*

FOR COMPLETE INFORMATION SEND FOR BULLETIN 46-48

THE VICKERS POWER PACK combines several basic hydraulic units of long-proven quality, durability and outstanding performance. These basic Vickers units provide the hydraulic Power Pack with an adaptability only now economically possible.

THE NEW Vickers Power Pack is a high-performance hydraulic unit for power operation of a wide variety of machinery. Completely self-lubricating, the Vickers Power Pack combines a vane type pump, overload relief valve, various combinations of single and double operating valves, oil filter, air cleaner and oil tank—*all in one compact 45 pound "package."*

The Power Pack is available with nominal delivery ratings of 2, 3, or 5 gpm at 1200 rpm and for operating pressures up to 1000 psi. It develops hydraulic pressure to lift, lower, push, pull, stack, load, and hold practically any load . . . depending on the cylinder size used.

**VICKERS Incorporated**

1430 OAKMAN BLVD. • DETROIT 32, MICH.

*Application Engineering Offices:* ATLANTA • CHICAGO • CINCINNATI • CLEVELAND • DETROIT • LOS ANGELES • NEWARK • PHILADELPHIA • ROCHESTER • ROCKFORD • SEATTLE • TULSA • WORCESTER

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

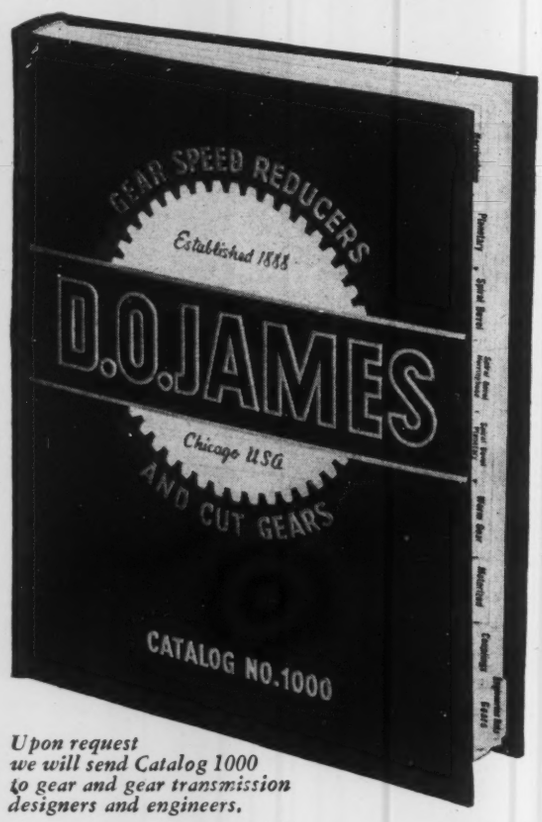
3052

MAKERS OF EVERY TYPE OF GEAR AND GEAR SPEED REDUCER

# D.O.James

*Established 1888*

## CATALOG NO. 1000 — *It's new and complete . . . and contains the latest information available...*




*Upon request we will send Catalog 1000 to gear and gear transmission designers and engineers.*

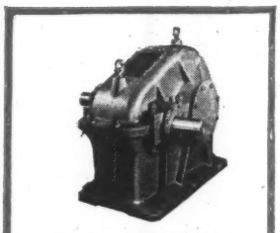
### On the Engineering and Manufacture of Gears and Gear Reducers, Racks and Flexible Couplings

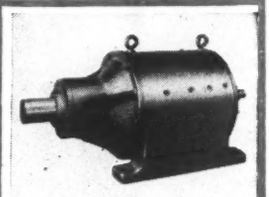
This 575 page indexed catalog contains essential practical information that will assist in solving gear and gear transmission problems. The contents of Catalog 1000 include extensive engineering data, rating tables, recommended practices for speed reducer selection, horsepower capacities of gears with examples, dimensions and list prices — also general information on design, construction and application of various types of cut gears, gear speed reducing transmissions and flexible couplings.

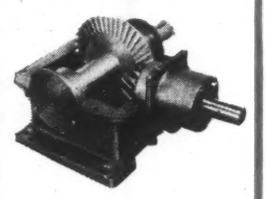
### IMPORTANT ENGINEERING DATA

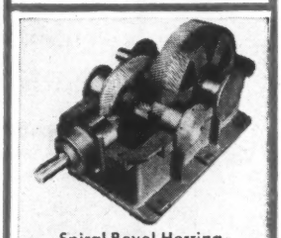
Catalog 1000 contains 100 pages of invaluable engineering data. This engineering section has been compiled and obtained from various accredited sources and includes tables, charts and formulas that have proven useful and helpful in gear design problems.

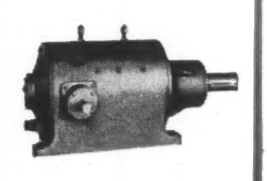
**D.O.JAMES MANUFACTURING COMPANY**
**1140 WEST MONROE STREET • CHICAGO (7), ILLINOIS**

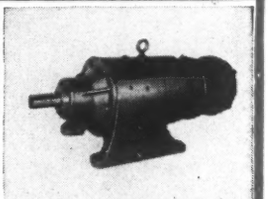

Continuous-Tooth Herringbone Speed Reducers

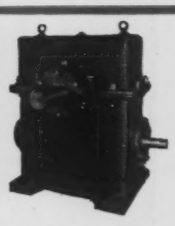

Planetary Gear Speed Reducers

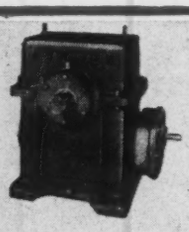

Spiral Bevel Gear Speed Reducers

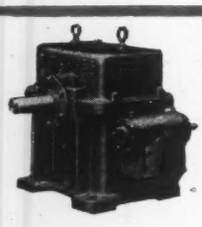

Spiral Bevel Herringbone Speed Reducers

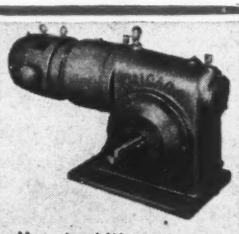

Spiral Bevel Planetary Gear Speed Reducers

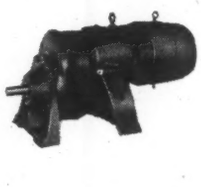

Motorized Planetary Gear Speed Reducers


Type "H" Worm Gear Speed Reducers


Helical Worm Gear Speed Reducers


Double Worm Gear Speed Reducers


Motorized Worm Gear Speed Reducers


Motorized Helical Gear Speed Reducers

MACHINE DESIGN

# Drawing-Change System

***A practical procedure designed to facilitate efficient, interlocked processing of drawing changes***

By A. C. Wedge
*Head, Production Engrg. Dept.*
*Ozalid Div. of General Aniline and Film Corp.*
*Johnson City, N. Y.*

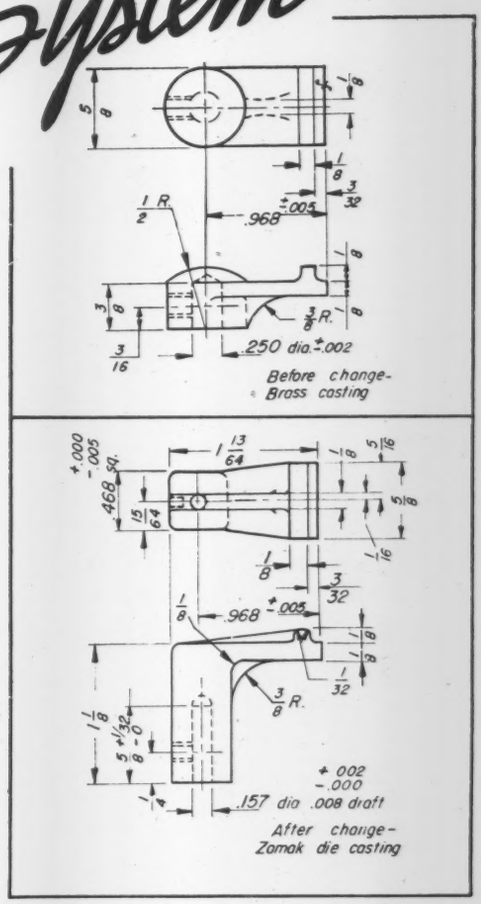



*Fig. 1—Drawing changes such as this can be processed most efficiently by using an engineered system*

PROGRESS, of course, is achieved by new discoveries and by changes or modifications of existing factors. In the field of machine design, these changes result in new models, or major and minor alterations in present designs to improve performance and operation, reduce cost, simplify production and decrease servicing costs of the machine in the field. In the broad sense, design changes, *Fig.* 1, which result in improved machines at reduced cost are to be encouraged, within reason, whenever a saving over and above the "cost of changing" can be realized during the active production life of the particular model.

Regardless of how "perfect" an original design is considered to be, the need for progressive "changing" is always present. In recent years particularly, changes have been required because of improved methods, and improvements or substitutions of raw materials, purchased parts and finishes. In view of these factors any company which manufactures equipment in production quantities must have a workable engineering change system. To be effective, such a system must fulfill the following minimum requirements:

1. Give accurate and complete information
2. Provide simplicity and be fully understandable to those who use the information
3. Be adaptable to the many different types of changes
4. Be expeditious so that the change may be processed in a minimum of time
5. Provide a follow-through in all phases of production
6. Operate at a minimum cost commensurate with the service rendered.

Many such systems are in operation, but (to the writer's knowledge) there is no one "perfect" system. Each industrial organization must adopt that plan which best suits its size, product and organizational setup. The foregoing check list should prove helpful in installing a new

Change Number 3042 Part Number #20246-3

Date December 16, 1946 Part Name Cooling Duct - Burner Detail #1

DRAWING CHANGE REQUEST WITH MARKED PRINT ATTACHED

Description of proposed change: Add five holes (.106 dia.) and dimensions for same. Add cross sectional view through center.

Reason for change: Holes to be used for mounting new style light shield.

Approved by:

A Curtis Production Engineering

A B Jones Design Engineering

JC309R-3-46 Requested by C. O'Malley C. O'Malley

(See reverse side for Cost Analysis where needed)

*Fig. 2 — Drawing Change Request form used by personnel in engineering departments or shop foremen for proposing drawing changes*

system or reviewing an existing system.

The plan to be described is used by the Ozalid Division, manufacturers of reproduction equipment and sensitized products. It was first started on a trial basis after the existing system was reviewed in detail. The final plan was prepared and supervisors of all related departments were given an opportunity to review and suggest revisions so that the final plan was a composite one best suited for use by the organization.

Changes may originate within the drafting, designing, production engineering or industrial engineering departments or from any of the shop foremen using the Drawing Change Request form shown in *Fig.* 2. This form lists the date, part number, part name, description of change, reason for change, name of originator and space for assigned number and approval. On the back, *Fig.* 3, is space for presenting the cost factors of the change relating to its effect on tooling, drafting and production costs for use in those instances where the real value of making the change is questioned. A marked print, showing the recommended change, is attached to the request. Final approval of the change request is the joint responsibility of the design and production engineers who analyze the request as to the cost of changing, effect on the operation of the machine and the overall advantages and savings to be realized. If the change is approved, a change number is then assigned from a master number book and the processing begins. If the suggested change is turned down, the reason is noted on the bottom and the request is returned to the originator. If necessary, discussions are

ESTIMATED SAVINGS IN DOLLARS PER PIECE

Base Quantity - Pieces

| Present Method | Proposed Method |
|---|---|
| Labor | |
| Material | |
| Overhead | |
| Tools | |
| | |
| Total | |

Savings

Remarks

Net Savings

ESTIMATED COST TO MAKE CHANGE

Tools Affected

| | | | |
|---|---|---|---|
| Tool Numbers | | | |
| Tool Names | | | |
| Effect | | | |
| Estimated Cost of Rework or Replacement | | | |

Total Cost

Drafting Room Time and Cost

| | Time | Cost |
|---|---|---|
| Check Original Change | | |
| Change Dwg. & Ass'bly. | | |
| Change Parts List | | |
| Change Assembly List | | |
| Change Material Lists | | |
| Issue & Prints | | |
| Total | | |

*Fig. 3—Printed on the back of each Drawing Change Request (Fig. 2), this form is used for listing cost factors attendant to a drawing change*

held to determine the advisability of the change.

The number assigned to the Drawing Change Request form corresponds to that on the Change Notice forms, *Fig.* 4, which are printed in sets of six copies, one for each of the departments affected by the change. These forms are filled in to include the information on the approved request, plus additional information as to approximate stock balance and the jobs "in process". The four general consideration involved in making the change are:

1. Action to be taken on jobs in process
2. Expediting of change
3. Disposition of current stock
4. Effect on purchased parts on order.

The check list printed on the forms is a breakdown of these four items into details. This list is completed by the production engineer who checks those items which apply to the particular change. He must be familiar with the urgency of the change and its effect on current production and assembly. Copies are issued to the following:

1. Production engineering master file
2. Drafting room
3. Tool design and tool production
4. Methods (operation sheet writing)
5. Dispatching
6. Mechanical stores.

In *Fig.* 5 is shown the Processing Check Guide. This guide lists the description of the change with the check items to be used, depending on whether or not the interchangeability of the part is affected or if production jobs are pending. The term "jobs pending" designates current jobs for parts which are being fabricated in the shops which subsequently will be sent to stock prior to subassembly or final assembly on the machine.

"Stop Production" is used only on those changes where further work on the part would be of no value since the part will no longer be interchangeable. If it is decided to include the change on current jobs a "marked print" is issued to the shop so as not to hold up production.

When interchangeability is not affected the existing stock is exhausted in order to use up all old style parts and make ready for the new style parts to be received on the next job or shipment from the outside vendor. If interchangeability is affected, parts in stock are reworked or obsoleted, depending on the particular case. If obsoleted, the parts are turned over to a salvage committee, which determines the value of the material for other uses or, in the case of purchased parts, negotiates to return or sell the parts to an outside source. In reworking parts in stock, consideration must be given to the value and immediate need for these parts. In some cases it may be more economical to scrap them since the cost of reworking may exceed that of new ones. On purchased parts where an important change is made affecting interchangeability, the purchasing department is immediately notified with a confirming memo so that current orders for parts in production by the vendor may be reviewed and changes made as soon as possible.

In changes where tooling is affected, tool design and tool production, in co-operation with the methods or operation-sheet writer, expedite the change of existing tools. If this cannot be done soon enough (according to the expedite date) or if new tools are needed which require considerable time, temporary methods and tooling are employed in order not to hold up production. For example, a series of holes might be punched individually pending completion of a multiple-punching die, or punching and forming might be done in separate operations pending completion of a compound die.

A key part of the plan is the use of stubs attached to

**DRAWING CHANGE NOTICE** No. 3042 **1**

THE FOLLOWING CHANGE IS BEING MADE:
Add 5 holes (.106 dia.) and dimensions for same. Add cross sectional view through center

PART NUMBER 20246-3
PART NAME Cooling Duct-Burner Detail #1
APPROX. STOCK 148
JOBS PENDING YES X 700 NO

REASON FOR CHANGE: Holes to be used for mounting new style light shield.

REQUESTED BY: C. O'Malley

| | |
|---|---|
| ✓ STOP PRODUCTION | EXHAUST PRESENT STOCK |
| COMPLETE CURRENT JOBS | OBSOLETE PRESENT STOCK |
| ✓ INCLUDE ON CURRENT JOBS | REF. CHANGE |
| ✓ DO NOT ISSUE NEW JOBS | ✓ REWORK PRESENT STOCK |
| ✓ FOLLOW CHANGE PROCEDURES | |
| ✓ EXPEDITE CHANGE BY 12/20 | PURCHASED PART—INFORM PURCH. DEPT. |
| REF. MEMO BY ____ ON ____ | QUANTITY CHANGED—INFORM REQ. GROUP |

DES. ENGINEER A. B. Jones DATE 12-16 — A. B. Jones
PROD. ENGINEER A. C. Wedge DATE DEC 20 1946 — A. C. Wedge

JC 540

**DRAWING CHANGE NOTICE** 3042 **1**

PART NUMBER 20246-3
Cooling Duct-Burner Det. #1

| | INITIAL | DATE |
|---|---|---|
| DRAWING CHANGED | | |
| TOOL DES. CHANGED | | |
| TOOLS CHANGED | | |
| OPER. SHEET CHANGED | | |
| NOTIFIED PURCHASING DEPT. | | |
| OLD STOCK EXHAUSTED | | |
| STOCK OBSOLETED PCS. | | |

1. PROD. ENG.
2. DRAFTING
3. TOOL DEPT.
4. METHODS
5. DISPATCHING
6. MECH. STORES

*Fig. 4—Drawing Change Notice lists information on an approved request. A copy is routed to each of six departments affected by the drawing change*

**Drawing Change Processing Check Guide**

| Description of change | Interchangeability affected | Interchangeability not affected | Jobs pending | No jobs pending | Stop production | Complete current jobs | Include on current jobs | Do not issue new jobs | Follow change procedure | Exhaust present stock | Obsolete present stock | Rework present stock | Purchased parts | Quantity changed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Change in materials, material size | x<br>x | <br>x<br>x | x<br>x | x<br>x | x | <br>x | | x<br>x<br>x<br>x | x<br>x<br>x<br>x | <br><br>x | x or<br>x or | x<br>x | | x<br>x<br>x |
| Change or additions in tolerances, dim's. views or finish | x<br>x | <br>x<br>x | x<br>x | x<br>x | x | <br>x | if pos. | x<br>x<br>x<br>x | x<br>x<br>x<br>x | <br><br>x | x or<br>x or | x<br>x | | |
| Change in quantity req'd. for any model | | | x | x | | | x | | x<br>x | | | | | x<br>x |
| Purchased parts incl. dim'l. spec's. & mat'l. change (issue ref. memo to Purch. dept.) | x | x | | | | | | x | x<br>x | x | x or | x | x<br>x | |
| Redesign, eliminating part | | | x | x | x | | | x<br>x | x<br>x | | x<br>x | | | x<br>x |
| Change in ass'y. drwg., ref. no. or part name | | | | | | | | | x | | | | | |

Note: Expedite change by date is used wherever the change must be rushed through Drafting, Tool Design, Tool Making and Processing or Rework to maintain adequate parts for production.
Reference memo by name on date is used wherever a memorandum is issued as further explanation.
Reference change number is used to provide a cross reference for related change numbers.

*Fig. 5—Left—Processing Check Guide is used as quick reference to determine proper procedure in putting through changes. Procedure depends on whether or not part interchangeability will be affected or production jobs are pending*

*Fig. 6—Below—Changes are noted in title blocks of drawings, giving description of change, date effected, and initials of the draftsman and the checker*

each copy for confirming the action taken by each department. As an aid to routing and processing, each copy has an offset number on both the notice and the stub. All departments process the change with respect to their particular functions. After action has been taken, the stub is initialed, dated and returned to the master file. All stubs are then filed with the master file copy in the production engineering department so that a complete history of the change is available at any time. As a further reference in processing, the change notice number is noted in the title block of the changed drawing (*Fig.* 6).

For major changes which require changing of many items, procurement of new purchased parts, building of new tools, etc., a memorandum is attached to the Change Notices explaining which and with what serial-number machine the changeover is to take effect, including any special instructions required.

This system fixes responsibility for each item which must be taken care of during the change procedure and provides a cross check of related items. It has been in operation for two years and is a proved means of conveying the important information of engineering changes at minimum cost. Of course, no drawing change plan can eliminate entirely the human element and the success or failure of this or any similar system depends upon action and follow through, using the information provided.

| Sym. | Revisions | Date | By | Checked |
|---|---|---|---|---|
| B | Added 5 holes .106 dia.-dims. & view AA | 12-17-46 | CO | 3042 |
| A | Removed burring & straightening notes | 10-16-46 | APM | 2724 |

Part of dwg. no. 20271-4

Material See above

Supersedes No.

Superseded By No.

Mat'l. Size # 20 U.S.Ga.(.036) X6 27/32 X55 3/8 Finish

Tolerance unless otherwise specified
Decimals: ____ Fractions: ± 1/32 Angles ± 1/2°

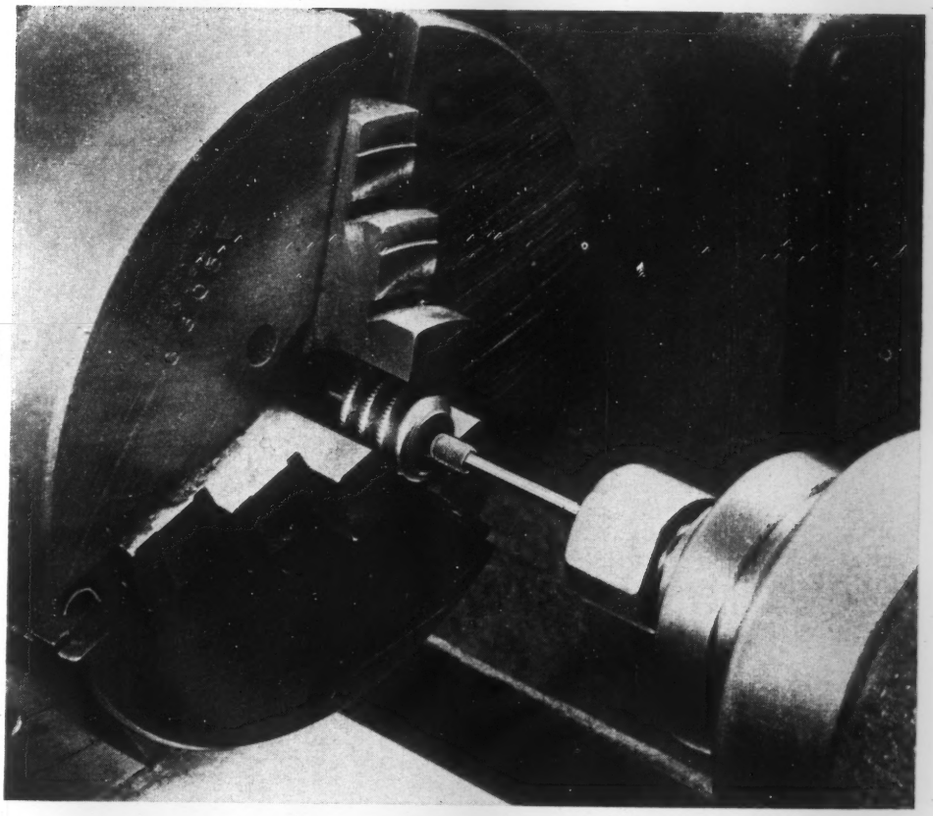
OZALID
Division of General Aniline and Film Corp.
Johnson City, New York

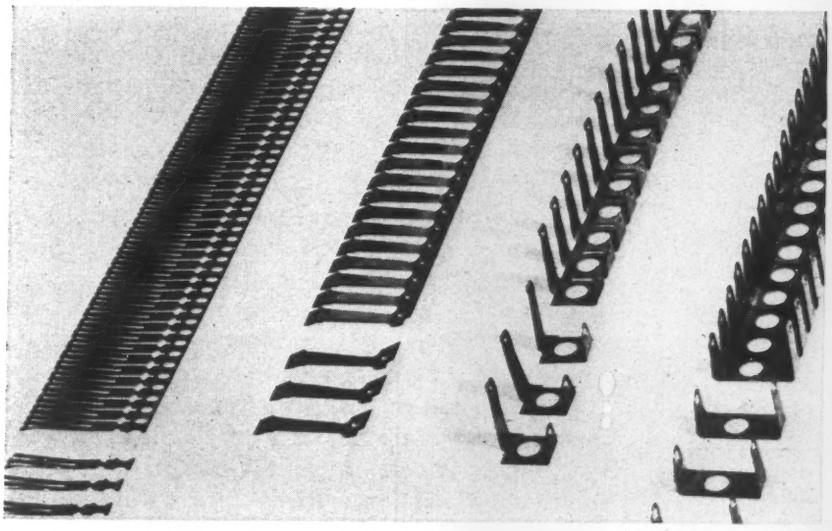
Cooling Duct – Burner Det. #1
Mach. – 20000

| | | | |
|---|---|---|---|
| Drawn By | H.E.B. | 5-22-46 | Scale Full size |
| Traced By | H.E.B. | 5-22-46 | Dwg. No. |
| Checked By | C.O. | 6-7-46 | 20246 – 3 B |
| App'v'd. By | [illegible] | | |

# Scanning THE FIELD for Ideas

**CARBIDE grinding wheels** have proved advantageous for use in grinding holes that cannot be satisfactorily finished with abrasives. Shown at right is a midget solid tungsten carbide wheel grinding the bore of a hardened gear. These wheels developed by Raymac Co., can finish holes to close tolerances in metal of any hardness. High modulus of elasticity of the carbide triples the stiffness of the cutter shank, permitting maximum cutting action without distortion or tapering of holes. The wheels may be resharpened several times with little change in diameter. They remove metal fast, increasing production by obviating set-up changes.

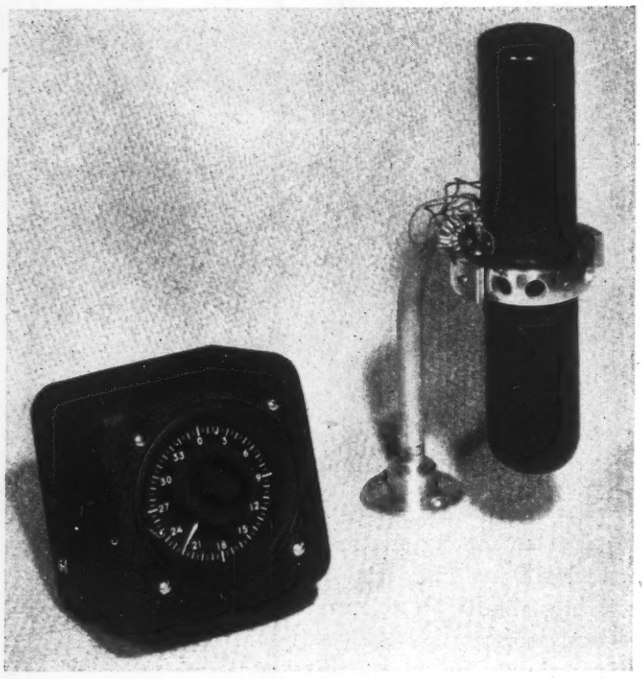




**Flat springs,** partially sheared, may be separated easily for use in assembly, effecting significant savings in handling time. These continuous-strip springs, left, are beryllium copper and were developed by Instrument Specialties Co. Inc. Attachment between parts is sufficiently strong to keep lengths intact during inspection, plating and handling. Lengths may be inserted in a dispenser at assembly benches, allowing individual springs to be broken off as needed. Also automatic feed-

ing for riveting, etc., provides marked savings.

Fixture heat treating of the springs is possible at a low unit cost, obviating individual handling and untangling. Examples illustrated are for a refrigerator control, automobile heater and electric clock motor. Labor cost savings in each case more than covered the cost of the parts.

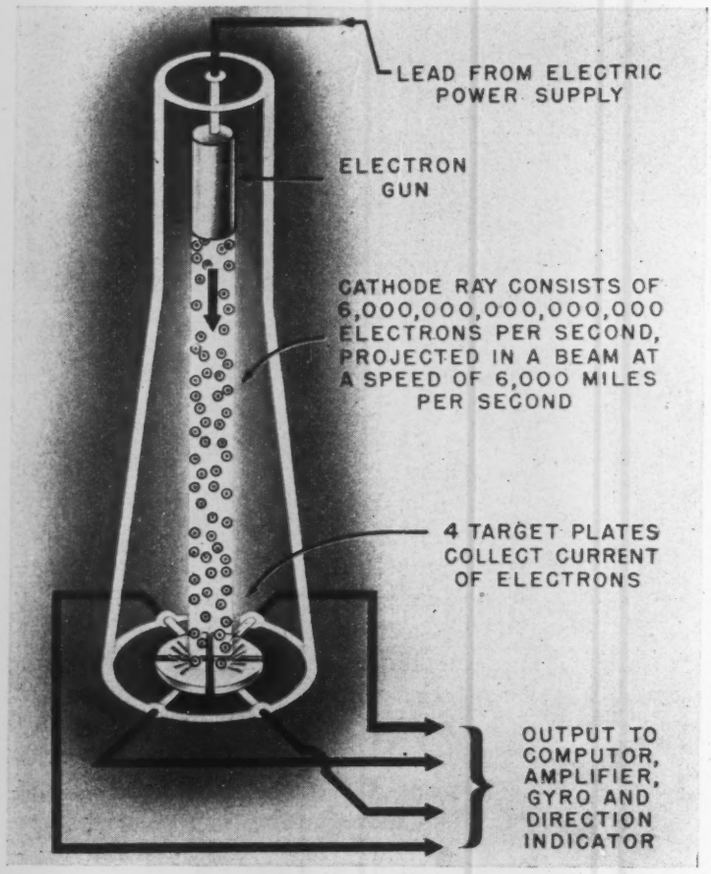


**Electron-gun compass,** right, no larger than a flashlight but capable of precise readings hitherto unattainable by the conventional compass, contains no moving parts. The instrument, developed by Minneapolis-Honeywell Regulator Co., depends upon a constant bombardment of electrons aimed at a target to provide direction signals and guide an airplane or ship on a preset course.

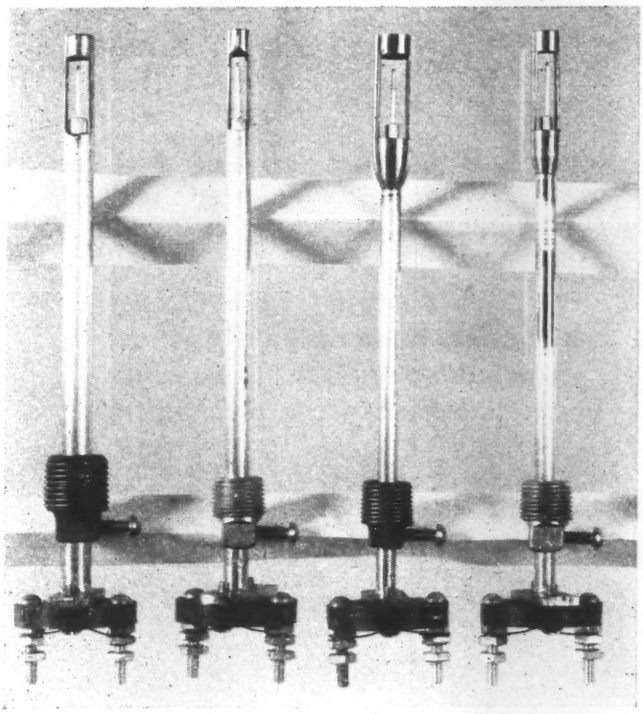
Specially designed cathode-ray tube, below, is seven inches long but, instead of containing a fluorescent screen, it has four target plates. Shaped like a pie cut into four equal parts the target is built to withstand shock and flight vibration. The compass actually points west instead of north, although, of course, the visual indicator is adjusted to read in the more conventional direction.

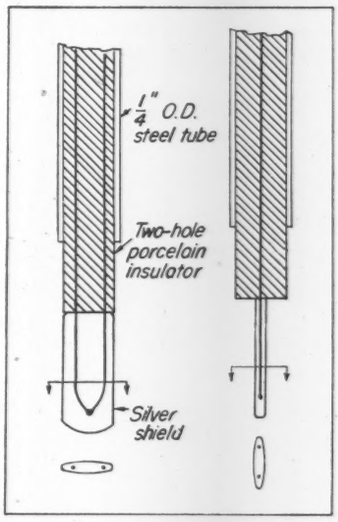
Suspended vertically on free-moving gimbal joints the tube fires a constant and focused stream of electrons at the four tiny target plates. This beam is equally divided between the target plates when the instrument is pointed in the direction of the earth's magnetic field but, in any other position, the earth's pull bends some of the beams so that they strike the target unevenly. Through a sensitive amplifier the different electron currents on each plate are measured and translated into energy sufficiently powerful to move the indicator needles and automatic controls.

Because the compass measures intensity of magnetic pull as well as direction it will be possible to use it as a magnetometer in prospecting for oil, ores, and other materials beneath the earth's surface.




**Pyrometers,** for measuring the temperature of high-temperature high-velocity gas streams such as encountered in gas turbines and jet engines, employ shields which respond quickly to change in temperature yet mimimize transfer of heat to or from the thermocouple junction by radiation. Developed by Andrew I. Dahl at the National Bureau of Standards in co-operation with the Bureau of Ships, Navy Dept., the pyrometer employs a small, light, silver shield. Shields formerly used are not only bulky and slow to respond to temperature changes but also offer considerable obstruction to the stream of gas. The silver shield, being a good reflector and poor emitter for radiant heat energy, keeps the temperature of the shielded junction within 5 degrees of that in a






stream of gas at 1500 F flowing through a pipe at 250 fps with pipe walls at 1200 F.

Five types of pyrometers are illustrated left above; they are designed to create a minimum of gas-flow disturbance and give substantially the same results as unguarded thermocouples. A schematic diagram of their basic design is shown right above. The junction is made by conventional methods and inserted ½-inch into a ¾-inch long silver tube that is slightly flattened. A thin mica strip is inserted within the silver tube on each side of the junction and the assembly is pressed to form a rigid unit with good thermal contact between shield and junction. Maximum width of the shield need not exceed the diameter of the porcelain tube used for insulating the thermocouple wires.

**Electronic counter,** right, accurately records x-rays at a 0.000001-second speed over a wide range of intensities. Difficulty of measuring x-rays has always been a scientific headache, the Geiger counter measuring only low intensities of radiation. Development by Westinghouse Research Laboratory of this instrument provides a tool for fundamental research and for development of future application of x-rays. An adaptation of the photomultiplier, an already existing tube, the new instrument is simple in construction. The tube is wrapped in a fluorescent screen which itself is covered with black paper. While the black paper blocks out all room light, x-rays penetrate to the fluorescent screen. Measuring the intensity of the fluorescence, the tube can record changes in intensities as rapidly as one every millionth-second.

When rays from the screen enter the tube, they strike a metal plate coated with cesium-antimony. Being light sensitive, molecules of this metallic compound cause some electrons to be shaken loose from their parent molecules. These free electrons then collide with another plate, knocking loose more electrons. This cumulative process is repeated at nine plates until the flow of electrons or electric current is amplified about one million times.

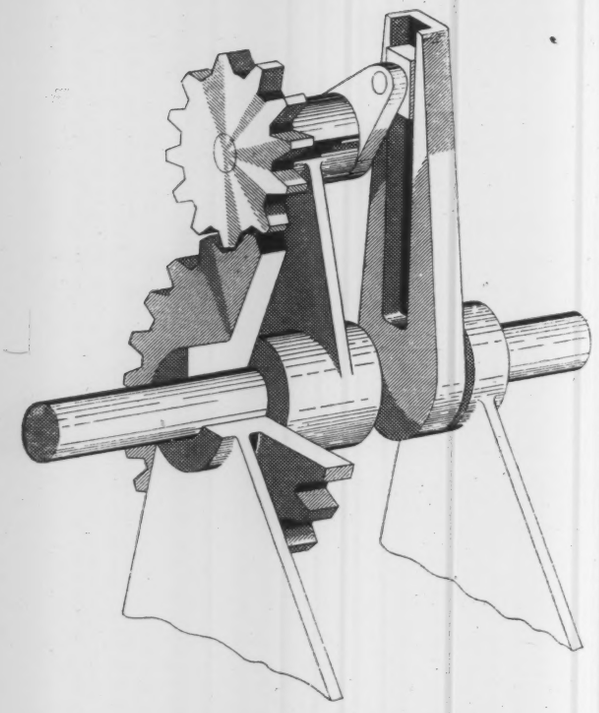


*Fig. 1—Above—Schematic representation of a cycloidal crank for a variable-speed drive*

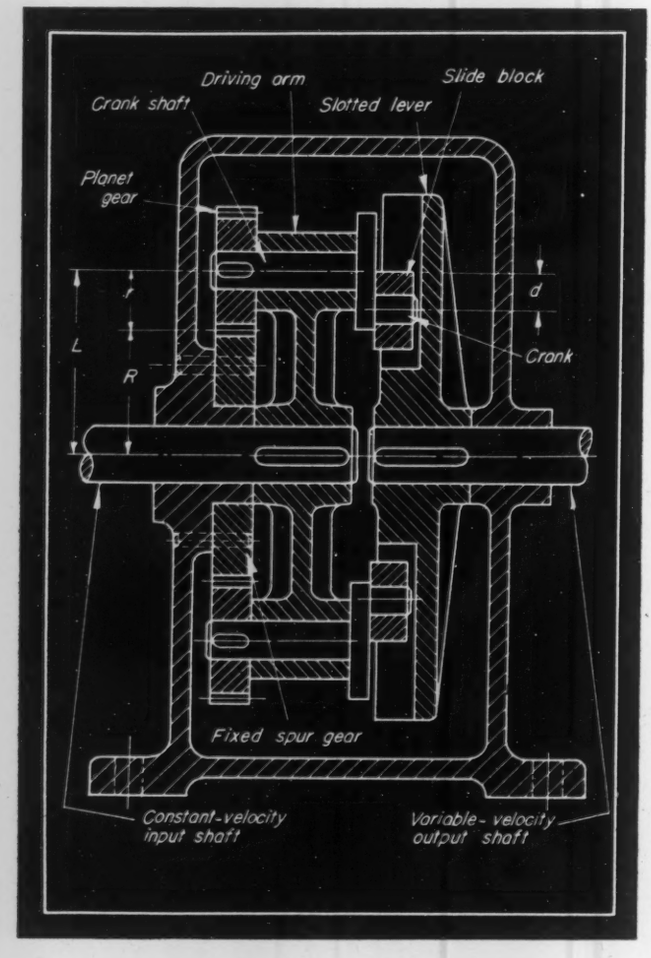
# Cyclic Variations i

***. . . obtainable from cycloidal cranks. Wide range of speeds, including reverse, is possible with this versatile mechanism***


**By E. H. Schmidt**

*Mechanical Development Laboratory*
*E. I. du Pont de Nemours & Co.*
*Wilmington, Del.*


*Fig. 2—Below—Fixed sun gear with two planetary gears provide a balanced mechanism with driving and driven shafts in line*




THERE are instances in machine design where, in order to improve operating conditions, it would be desirable to impart a definite and controlled variable speed to a rotating member. The conventional solution usually consists of using either elliptical gears or a type of variable linkage. Either or both may be satisfactory under certain conditions; they are limited, however, in regard to their adaptability, velocity range, and operating speed.

Variable-speed drives possessing better operating characteristics and greater flexibility are obtainable by the use of cycloidal cranks, *Fig.* 1. These consist of a planetary crank gear which meshes with either a fixed spur gear or a fixed internal gear. These two types of cranks are shown with respect to the gearing in *Figs.* 2 and 3.

The planetary gear is keyed to a crankshaft that is free to turn in a bearing of a driving arm rotating at a constant angular velocity. An eccentric crank on the crankshaft is located on the end opposite to the planet gear and engages a slotted lever through a slide block. Any motion developed by the crank is transferred to the slotted lever which in turn transmits it to the output shaft of the drive. Both types of mechanism permit the driving and driven shafts to be in line. This design allows for introducing the mechanism into existing constant-speed driveshafts and is a straight-forward arrangement for new designs.

Power for the constant-velocity driving arm is obtained from the input shaft to which it is fastened. This causes the planet gear to rotate epicyclically about the fixed gear. The crank thereby describes a definite path, dependent upon the gear ratio and the location of the crank. When the crank radius is equal to the pitch radius of the planet gear the locus will be either an epicycloid or hypocycloid, depending upon the type of fixed gear. At the instant when the crank is on the pitch point common to the two gears its velocity is zero regardless of the

# s in Speed

velocity of the driving shaft and therefore the slotted lever is at rest for that instant.

Maximum and minimum velocities of the slotted lever dependent upon the crank radius $d$. When this radius is equal to zero, the velocity of the slotted lever is constant and equal to the velocity of the driving arm. As the crank radius is increased, the percentage variation in the velocity of the slotted lever increases.

Output velocity is minimum when the crank is at a point closest to the common pitch point of the two gears and is maximum when displaced 180 degrees from this point about the crankshaft center. From the mathematical formulas the crank radius can be calculated for a given

---

NOMENCLATURE

- $A$ = Angular displacement of constant velocity driving arm
- $B$ = Angular displacement of slotted lever
- $C$ = Angular acceleration of output shaft (radians per sec per sec)
- $d$ = Crank radius from planet gear center
- $K$ = $R/r$
- $L$ = $R + r$ for fixed spur gear
- $L$ = $R - r$ for fixed internal gear
- $N$ = $d/L$
- $R$ = Pitch radius of fixed gear
- $r$ = Pitch radius of planet gear
- $V$ = Angular velocity of output shaft (radians per sec)
- $W$ = Angular velocity of constant velocity driving arm (radians per sec)

---

minimum or maximum velocity and the velocity of the driven member determined for any instant. An inspection of the two types of cycloidal cranks indicates that the internal type must repeat more than once per cycle as the planet gear must be smaller than the fixed internal gear.

FIXED SPUR GEARS: General mathematical formulas for the displacement, velocity, and acceleration of the fixed spur gear crank, *Fig.* 4, follow:

*Displacement*:

$$\tan B = \frac{\sin A - N \sin (K+1)A}{\cos A - N \cos (K+1)A}$$

*Velocity*:

$$V = \left[ \frac{1 + (K+1)N^2 - (2+K)N \cos KA}{1 + N^2 - 2N \cos KA} \right] W$$

The velocity is minimum when the angle $KA$ equals 0, 360, 720 degrees, etc., and is maximum when $KA$ equals 180, 540 degrees, etc.

$$V_{min} = \left( \frac{1 - N - KN}{1 - N} \right) W$$

$$V_{max} = \left( \frac{1 + N + KN}{1 + N} \right) W$$

*Angular acceleration at angle A*:

$$C = \left[ \frac{(1 - N^2) NK^2 \sin KA}{(1 + N^2 - 2N \cos KA)^2} \right] W^2$$

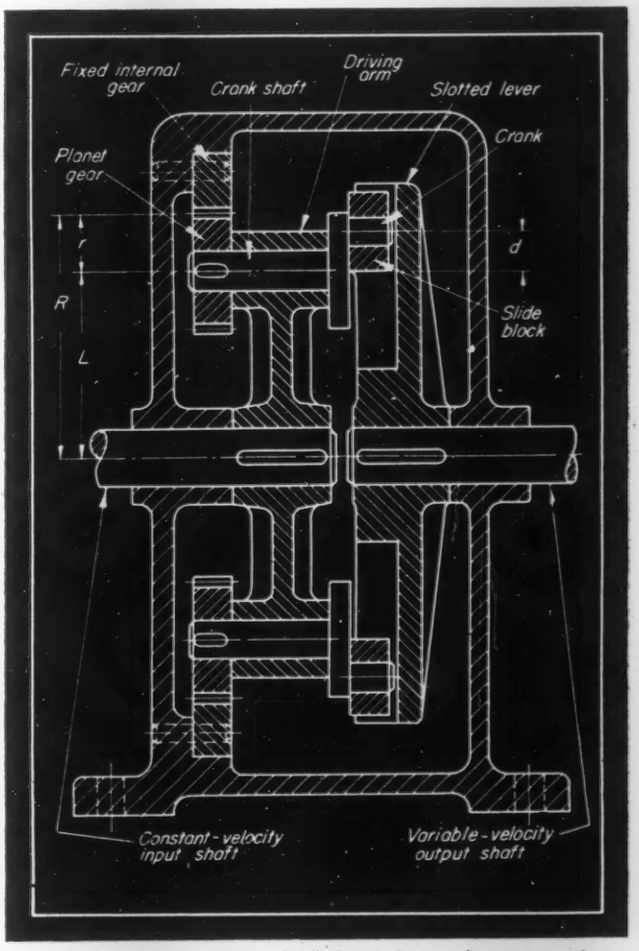



*Fig. 3—Variation of cycloidal-crank mechanism utilizing a fixed internal gear*

This is maximum when

$$\cos KA = \frac{-(1+N^2) \pm \sqrt{1 + 34N^2 + N^4}}{4N}$$

FIXED INTERNAL GEARS: For fixed internal gears, *Fig.* 5, the formulas are as follows:

*Displacement*:

$$\tan B = \frac{\sin A - N \sin (K-1)A}{\cos A + N \cos (K-1)A}$$

*Velocity*:

$$V = \left[ \frac{1 - (K-1)N^2 + (2-K)N \cos KA}{1 + N^2 + 2N \cos KA} \right] W$$

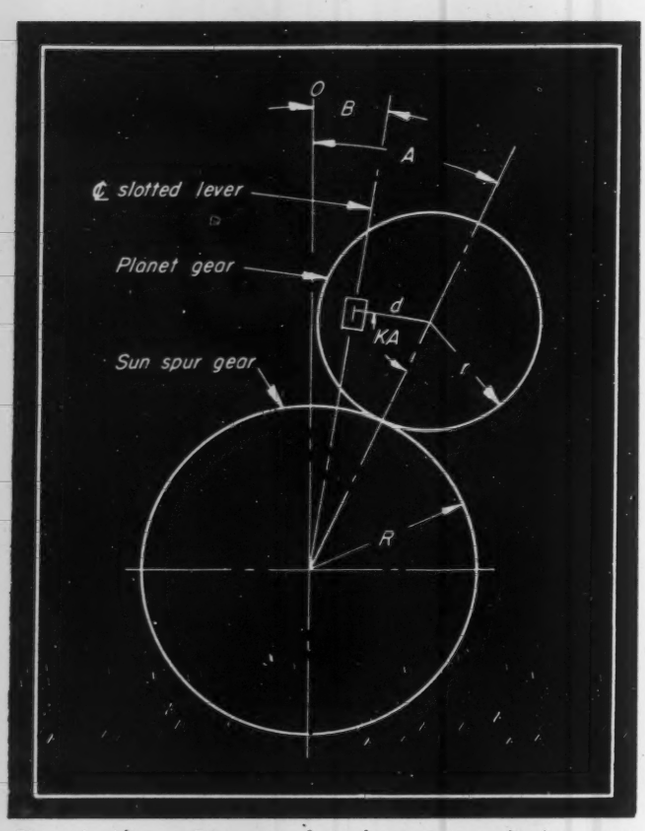
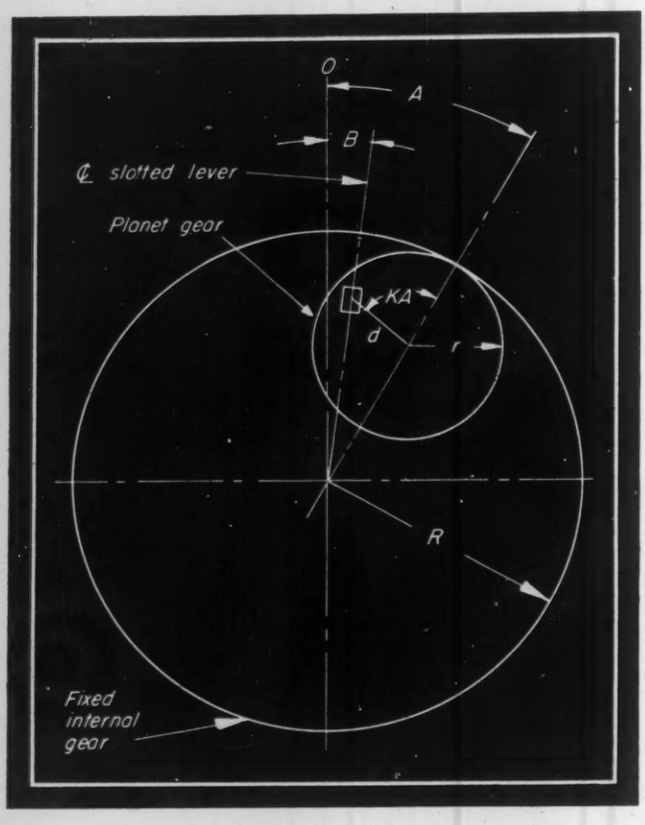



*Fig. 4—Above—Diagram for determining displacement, velocity and angular acceleration in fixed spur gear unit*

*Fig. 5—Below—Diagram for calculating cyclic speeds and acceleration in fixed internal gear unit*




The velocity is minimum when the angle $KA$ equals 0, 360, 720 degrees, etc., and is maximum when $KA$ equals 180, 540 degrees, etc.

$$V_{min}=\left(\frac{1+N-KN}{1+N}\right)W$$

$$V_{max}=\left(\frac{1-N+KN}{1-N}\right)W$$

*Angular acceleration at angle A:*

$$C=\left[\frac{(1-N^2)NK^2\ sin\ KA}{(1+N^2+2N\ cos\ KA)^2}\right]W^2$$

This is maximum when

$$cos\ KA=-\frac{(1+N^2)\pm\sqrt{1+34N^2+N^4}}{4N}$$

Analysis of the inertia forces developed by this type of mechanism indicates that the block, crank, and driving arm, which can readily be designed for safe stress and bearing loads, are subjected to the larger forces. Gear loads are relatively small as the point of maximum torque on the crankshaft occurs when the moment arm about the gear center is small. It is also of interest to note that in the cases where the driven member comes completely to rest, both velocity and acceleration are equal to zero at that instant.

## Determining Cyclic Speeds

The following procedure will illustrate a general approach for determining the design characteristics of a cycloidal crank for a given set of specifications. The number of times the variation in velocity is to occur per revolution will determine the gear ratio. In cases where the variation in velocity is to occur once per revolution the fixed spur gear type with a 1:1 gear ratio must be used. In general, the fixed internal gear type can be used only when the variation in velocity occurs at least twice per revolution. Once the gear ratio and type have been decided the crank length $d$ can be determined for the maximum or minimum velocity required from the mechanism by means of the following formulas:

If the maximum output velocity is the independent variable, for fixed spur gear,

$$d=\left(\frac{V-W}{LW-Vr}\right)Lr$$

For fixed internal gear,

$$d=\left(\frac{V-W}{LW+Vr}\right)Lr$$

If the minimum output velocity is the independent variable, for fixed spur gear,

$$d=\left(\frac{W-V}{LW-Vr}\right)Lr$$

For fixed internal gear,

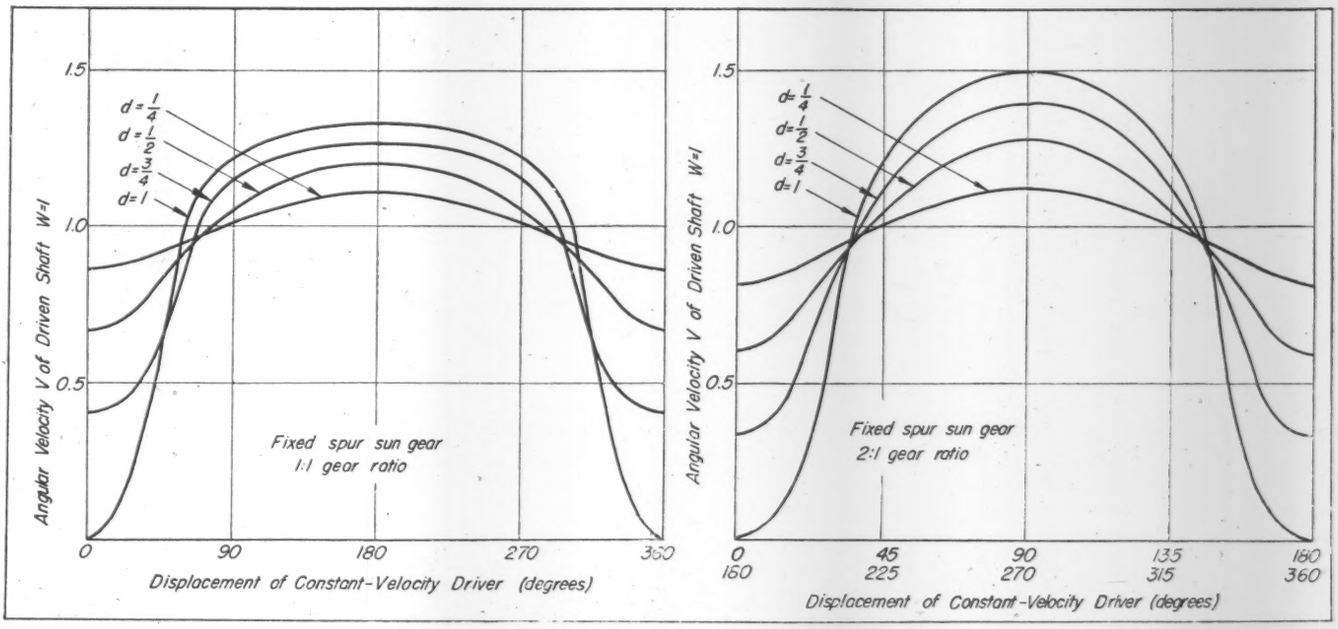



**Fig. 6—Velocity of driven shaft for angular displacement of driver for 1:1 and 2:1 gear ratios, fixed spur sun gear**

$$d = \left( \frac{W - V}{LW + Vr} \right) Lr$$

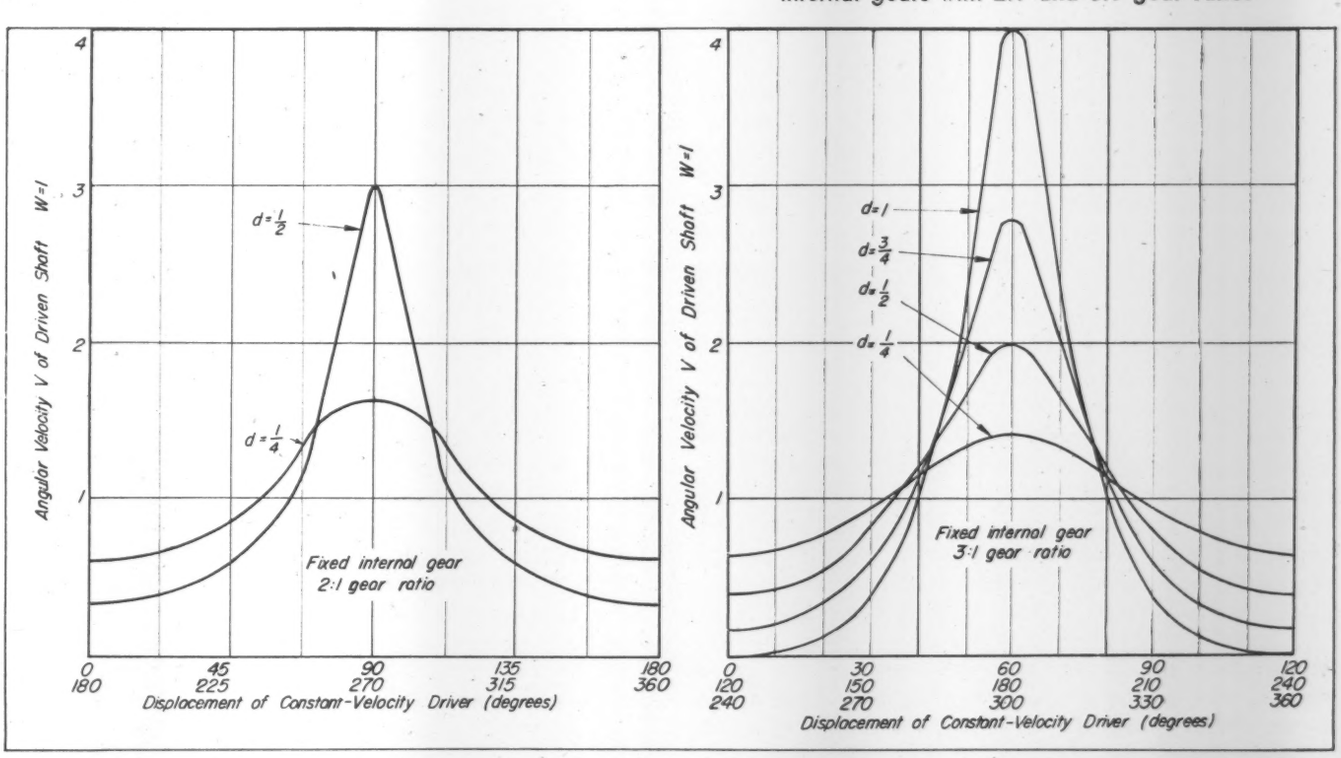
Once the value for $d$ has been established the displacement, velocity, and acceleration of the output shaft can be calculated by the use of the general formulas for any angle $A$ of the input shaft.

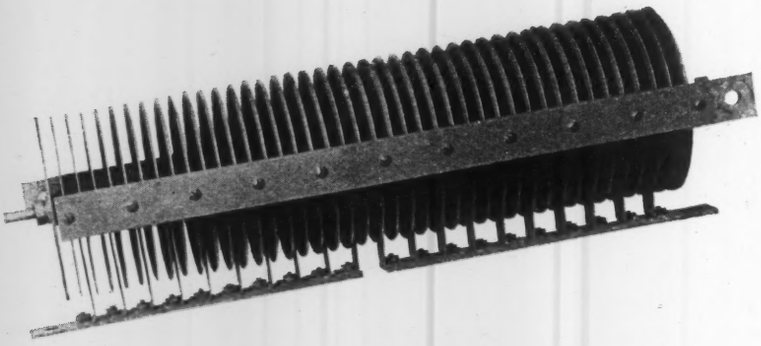
Velocity characteristics of a number of gear combinations with different crank lengths are shown in the four graphs, *Figs.* 6 and 7. The fixed spur gear type is represented in *Fig.* 6 for the two gear ratios 1:1 and 2:1. *Fig.* 7 shows the velocity curves for the internal gear type with gear ratios of 2:1 and 3:1. Angular velocity of driven shaft is represented for a constant velocity input of unity ($W = 1$). To obtain the angular velocity of the output shaft for a specific application, the values from the graphs are multiplied by the actual velocity of the input shaft.

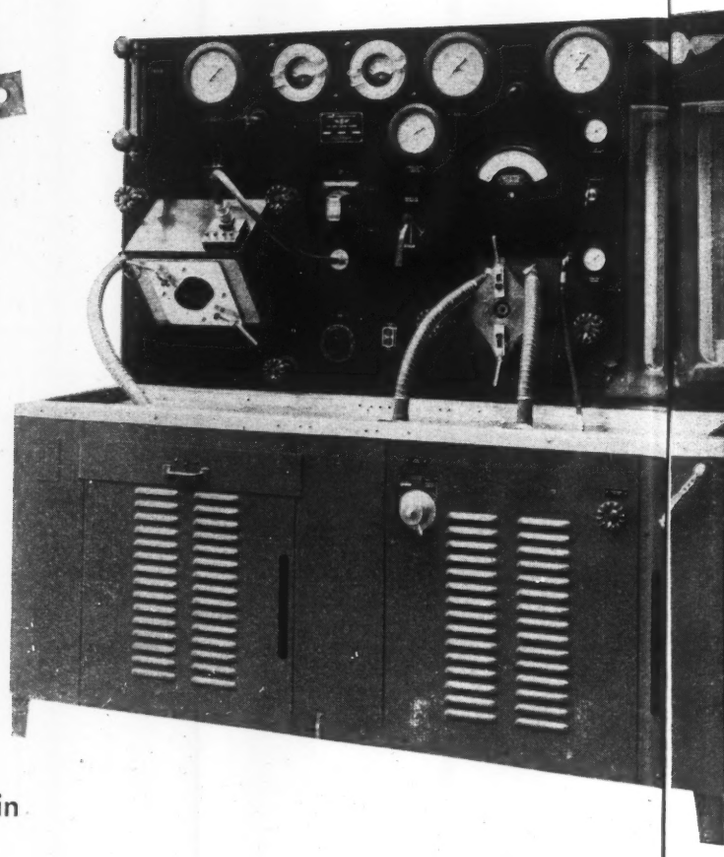
Relative value of the two types of mechanisms can be obtained from the various curves. The spur gear type is more applicable for minimum velocity applications as the overall velocity variation is less than for the internal gear type. It is limited, however, in maximum velocity

(*Concluded on Page* 182)

**Fig. 7—Angular velocity of driven shaft, utilizing fixed internal gears with 2:1 and 3:1 gear ratios**







# Selenium Rectifiers

***Improved characteristics broaden the field of application to machines***


**By Julian Lobenstein**

*Electrical Engineer*
*Seletron Division, Radio Receptor Co.*
*New York*


UNDER war stimulus many improvements have been made in selenium rectifiers, with the result that their range of application has been widened considerably. Until a few years ago the dimensions of selenium plates were limited to relatively small sizes, necessitating the use of a large number of plates for high current capacities. Recently, however, plate sizes have been increased to approximately thirty square inches. Also, in past years the maximum voltage applicable to individual plates was 18 volts, alternating current. Today, plates capable of sustaining much higher voltage are available, making them more useful as dry-plate rectifiers, *Fig.* 1, for machines such as illustrated in *Fig.* 2.

This means that for a given applied alternating-current voltage fewer plates need be used than was formerly the case, making possible both convenient and economical rectifiers for applications such as those found in textile machines, coin machines, candy-making machines, counting and grading equipment, electro-cleaning units, theatre arc projectors, electro-plating and other electro-chemical apparatus, as well as in battery chargers, welders, business machines, cathodic protection equipment, motor speed controls, radio sets, elevator controls, magnets for chucks, relays, brakes, clutches and controls of all kinds, separators, and valves. Previously in many of these devices rectification was limited to other methods.

A rectifier, *Fig.* 1, utilizes base plates of steel or aluminum on which is sprayed a layer of selenium and a counter-electrode layer of alloy. The base plate serves as one electrode and the metal alloy as the other. In addition, the plate is treated in such a manner that it presents a high resistance to the flow of current from its alloy front electrode to the aluminum back electrode and a low resistance to the current flow from the aluminum to the alloy electrode. The high resistance from front to back electrode is called the reverse resistance (or leakage), while the low resistance from the back to front electrode is known as the forward resistance. Theoretically, the greatest degree of rectification would be obtained if the rectifier had an infinite reverse resistance and zero forward resistance. Naturally, this condition is impossible to achieve in production, but the more nearly it can be approached, the more efficient the rectifier. These characteristics are shown in *Fig.* 3. It should be noted that the reverse current and voltage are plotted to a different scale than that used for the forward resistance, the reverse-current scale being enlarged.

Selection of the proper stack depends upon a number of factors and it is therefore desirable to have full information regarding the proposed use and conditions of application. For instance, for a given direct-current output, different stack designs are required if the dc circuit feeds into a resistive load, an inductive load, a capacitive load or load with a counterelectromotive force such as is encountered in battery charging or motor speed control. Size and spacing of the plates will also depend upon the ambient temperature and the time cycle of operation.

In general, for design purposes, a stack is considerd as under continuous use if it is in operation for fifteen minutes or more at a stretch because during this time the

*Fig. 1—Far Left—Stack of selenium cells for a rectifier having an 80-ampere dc output. Input is 24 volts ac*

*Fig. 2 — Left — Combination Greer fuel pump test machine utilizing selenium cell rectifiers to supply direct-current power for aircraft units*

stack will reach its maximum temperature. However, if it is on and off during a period of less than fifteen minutes, smaller plates may be used.

Other factors which affect stack design are the number of plates per stack. When cooled by natural convection and only a few plates are assembled in a stack, the plates may be rated at a higher current capacity than when assembled in larger stacks, because in the smaller stacks air circulates more freely around the plates. Under forced cooling, however, plates may be conservatively rated at two and a half times normal rating. If stacks are used with forced ventilation, it is essential to design the circuit in such a manner that, if the circulation of air is stopped for any reason, the supply of current to the rectifier will also be interrupted. If this is not done the stack will quickly overheat.

As in all types of rectification, stacks may be supplied for half-wave center tap and bridge circuits and each in turn for single or three-phase rectification. Where considerable power is involved, three-phase rectification is desired because, besides balancing the circuit, it operates at higher efficiency. In single-phase circuits, with resistive load, it is not unusual to obtain an efficiency of 62 per cent, whereas for battery charging the efficiency may be as high as 75 per cent. Three-phase circuits, on the other hand, regardless of application, may approach 85 per cent.

In considering three-phase application, however, it should be remembered that the half-wave circuit is not as efficient as the full-wave circuit. The stack, for half-wave, probably will be less expensive but the transformer will be more expensive. In designing equipment for sizable power applications the difference in sale price of the equipment for half-wave as compared with full-wave should be balanced against possible differences in the purchaser's power bills. Individual cases should be considered with these points in mind.

During the first 10,000 hours of operation rectifiers age to a certain degree. During this period the forward and reverse resistances increase gradually after which time they become stabilized. In some applications this increase in resistance, with a corresponding drop in output voltage, may be ignored, while in other cases it may compensate for it by 5 to 10 per cent increase in the ac input voltage.

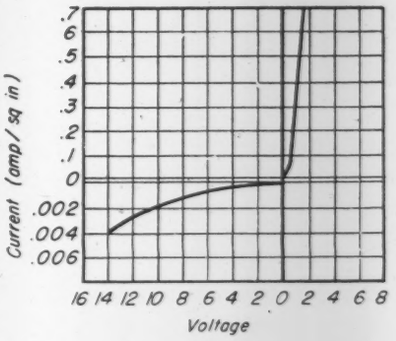
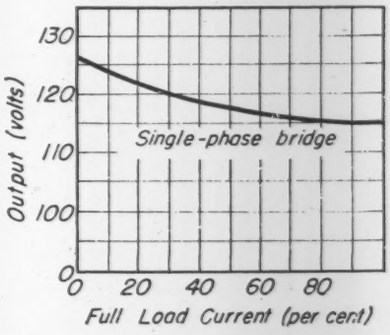



*Fig. 3—Above—Direct-current forward and reverse characteristics of selenium cells*

*Fig. 4—Below—Output voltage variation with load for a typical rectifier*




Voltage regulation varies from approximately 15 per cent with new stacks to 20 per cent when aged. The use of cooling fins or forced-air cooling may increase the regulation to 25 per cent. *Fig.* 4 shows the variation of output voltage with current changes for a typical single-phase bridge rectifier.

The ac input voltage to be applied to Selectron selenium rectifiers for a given dc output voltage is governed by the circuit arrangement, the type of load and the voltage drop. Various rectifier circuit arrangements, approximate wave shape, and circuit factors involved for resistive or inductive loads are shown in *Fig.* 5. The voltage drop is determined by the number of series rectifier plates and the drop across each plate. Curves are given in *Fig.* 6. Sizes and ratings are shown in TABLE I for the corresponding circuit arrangements in *Fig.* 5.

With respect to the various types of dry-disk rectifiers, tests indicate the following relative weights at one amp-

TABLE I

Selenium Plate Ratings

| Plate Diameter or Dimensions (in.) | Plate Spacings§ | Max. Plates Per Stack† | Continuous DC Amperes at 35 C Ambient | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Single Phase* | | | Three Phase | | |
| | | | Half-Wave | Bridge or Center Tap | Half-Wave | Bridge | Center Tap | DC Valve |
| 1 | Normal | 36 | .075 | .15 | .20 | .225 | .27 | .12 |
| | Wide | 28 | .11 | .22 | .29 | .33 | .4 | .17 |
| 1⅜ | Normal | 36 | .15 | .30 | .40 | .45 | .55 | .23 |
| | Wide | 28 | .23 | .45 | .60 | .67 | .82 | .34 |
| 1¾ | Normal | 40 | .30 | .60 | .80 | .90 | 1.1 | .45 |
| | Wide | 28 | .39 | .78 | 1.0 | 1.1 | 1.4 | .58 |
| 2½ | Normal | 40 | .60 | 1.2 | 1.6 | 1.8 | 2.2 | .90 |
| | Wide | 28 | .78 | 1.6 | 2.1 | 2.4 | 2.8 | 1.2 |
| 3⅜ | Normal | 40 | 1.2 | 2.4 | 3.2 | 3.6 | 4.5 | 1.8 |
| | Wide | 28 | 1.5 | 3.1 | 4.1 | 4.6 | 5.8 | 2.4 |
| 4⅜ | Normal | 40 | 2.0 | 4.0 | 5.3 | 6.0 | 7.5 | 3.1 |
| | Wide | 28 | 2.6 | 5.2 | 6.9 | 7.8 | 9.7 | 4.0 |
| 4½ x 5 | Normal | 28 | 3.0 | 6.0 | 8.0 | 9.0 | 11.3 | 4.7 |
| | Wide | 20 | 3.7 | 7.5 | 10.0 | 11.3 | 14.1 | 5.9 |
| 5 x 5¾ | Normal | 28 | 4.0 | 8.0 | 10.6 | 12.0 | 15.0 | 6.2 |
| | Wide | 20 | 5.0 | 10.0 | 13.2 | 15.0 | 18.0 | 7.5 |

†Max. Plates Per Stack for all sizes is 16 where vibration is present.

§Wide spaced ratings are applicable to normal spaced stacks of less than 5 plates. For fan cooling (120 fpm) multiply normal spaced ratings by 2.5.

*Single-phase current ratings are for resistive or inductive loads. Ratings for battery or capacitive loads are 80% of the values shown.

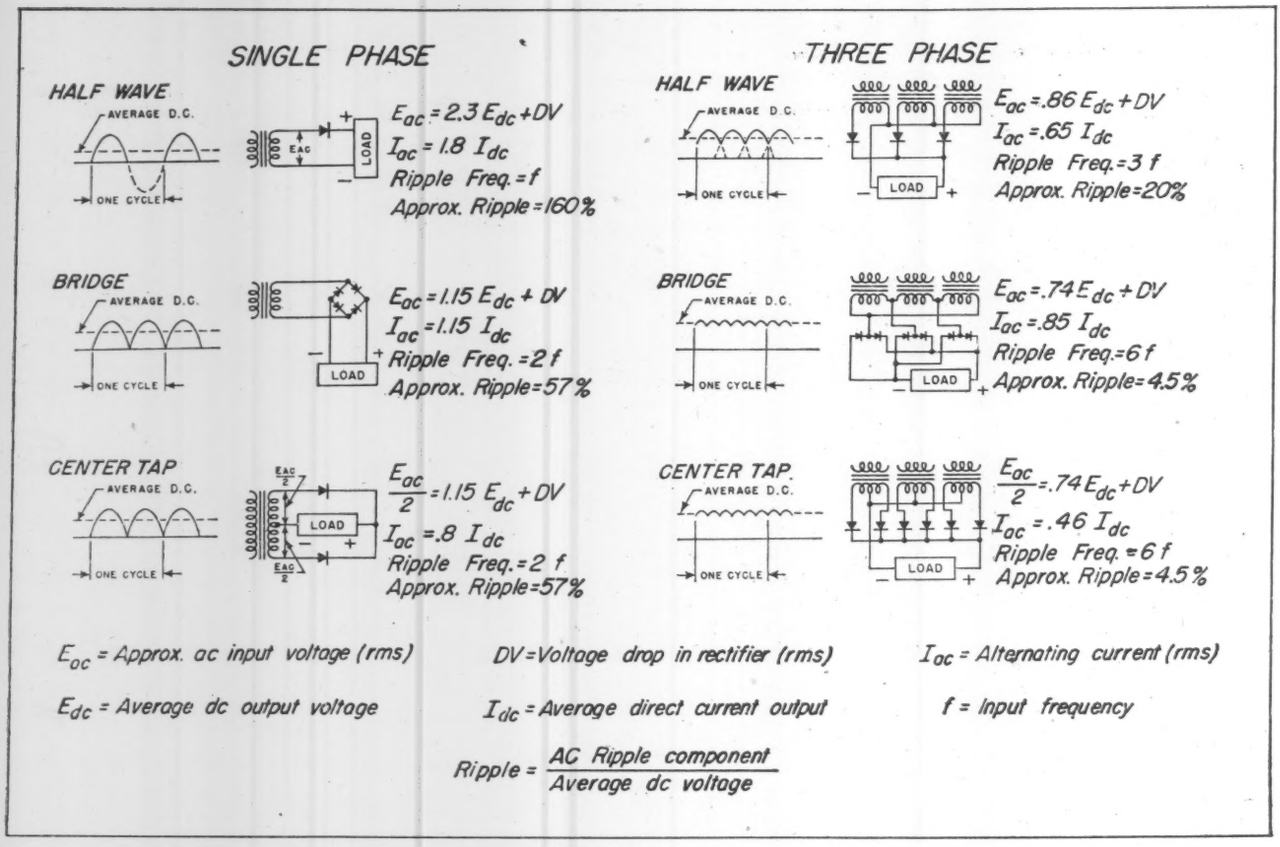



*Fig. 5—Six common circuits in which selenium rectifiers are used, together with approximate wave shapes under resistive load, ripple frequency, ripple percentage and approximate ac/dc ratio*

ere output: Selenium, 1; magnesium copper sulphide, 1.4; copper oxide, 3.4.

General characteristics of various types of rectifying equipment are listed in TABLE II. In addition to the high efficiency, long life and low weight of selenium rectifiers using aluminum plates, the advantage of being instantly ready for use at any time, because they have no warming up period, is often important. Also, efficiency is uniformly high over a wide load range, involving no standby losses when not under load. Furthermore, the almost 100 per cent power factor is a favorable feature.

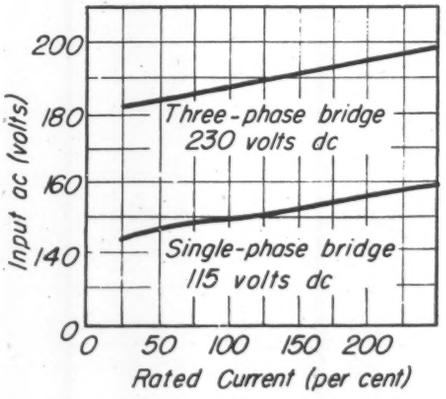
From an electrical mechanical and economic standpoint there is no hard and fast rule by which a decision may be made that selenium rectifiers should be applied. Present uses, however, indicated a wide general field in which they are proving advantageous.

TABLE II

**General Characteristics of Rectifying Equipment**

| Type of Rectifier | Power Rating | Operation | Maintenance | Notes |
|---|---|---|---|---|
| Dry-disk rectifiers: Selenium Copper-oxide Magnesium-copper sulphide | From milliwatts to 20 kw | Rectifying action takes place at metallic junction to provide current flow in one direction only | Very little | No moving parts. Quiet in operation. No warm-up time range of currents and voltages possible by series or parallel groups of stacks |
| Hot-cathode mercury-vapor tube rectifiers | to 40 kw | Unidirectional current flows from heated filament to plate only | Tube replacements from time to time | Current output ranges from 0.125 to 20 amp. Warm-up time varies from 10 sec to 5 min. Operation quiet. No moving parts. Vertical mounting often necessary |
| Igniter tube rectifiers | to 120 kw | Unidirectional current flows from graphite anode to mercury pool through controlled ionization of mercury vapor | Maintenance of cooling water supply essential to safeguard tubes. Replacement of electrodes or tubes from time to time | For heavy surge current applications as control of spot and seam welders. Auxiliary starting apparatus necessary |
| Motor-generator sets | 20 watts to 150 kw | Direct-current generator driven by single-phase or three-phase motor | Same as for other rotating equipment | Voltage regulation good. Output voltage easily controlled |

*Fig. 6—Input voltage for a typical rectifier*



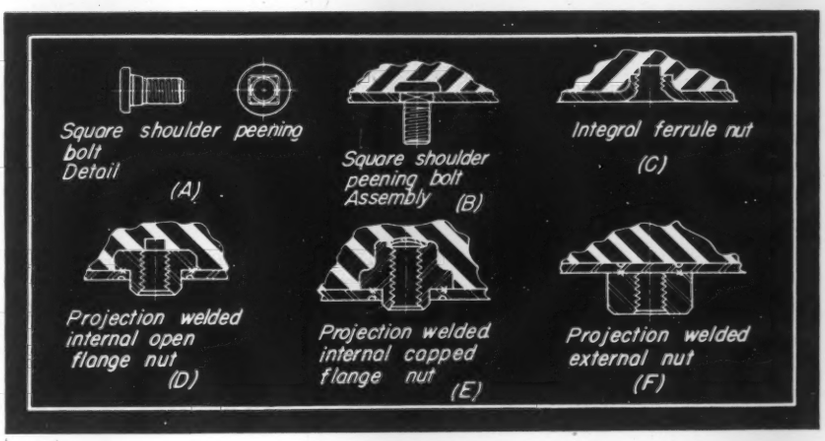



*Fig. 1—Typical mounting attachment elements for bonded rubber-metal parts*

# Practical Design of Rubber Parts

***Points often overlooked or not commonly understood are discussed in this article, which is based on a recent A.S.M.E. paper***

By Edward E. Blaurock
*Chief Engineer, Motor Products Div.*
*United States Rubber Co.*
*Detroit*

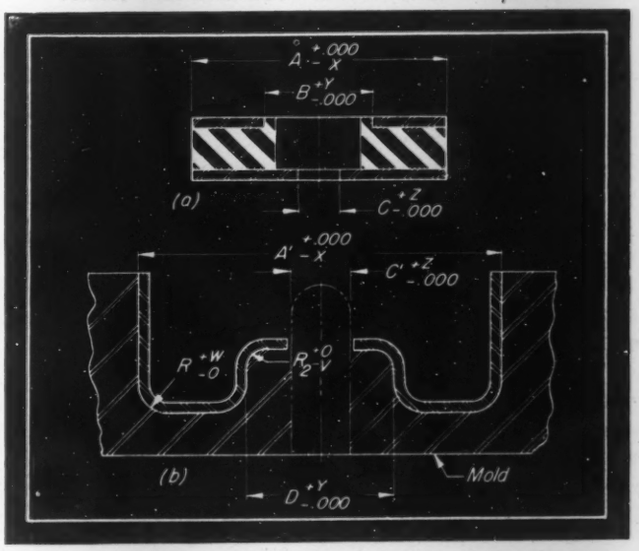
CONSIDERABLE technical data have been published covering the various physical and chemical properties of structural rubber compounds. The fundamentals of manufacturing are also recorded to demonstrate some of the basic possibilities and limitations of part design compatible with present production techniques and equipment. This information is generally sufficient to enable the designer to select materials, calculate structural dimensions, and set up attainable performance specifications for a required part.

Experience indicates, however, that the average engineer is not sufficiently aware of some of the more practical and vitally important details involved in both design and manufacture. This is undoubtedly due to the fact that rubber has been used for a relatively short time as an engineered product for structural purposes, hence little design detail information has been published. The designer is therefore required to rely on concepts applying to many common engineering materials, but which are often not applicable to rubber. Designs arrived at are frequently incomplete, costly, and difficult to produce by standard processes. They may also be something different from actual needs. Many of these errors can be avoided by observing certain fundamental practices. It is with some of the more common of these considerations, the so-called "practical aspects", that this article is primarily concerned. Since adhered or bonded rubber-metal parts comprise the largest portion of products in this field, discussion will be limited to that type unless specifically stated otherwise.

In analyzing any structural rubber problem, it is necessary to take into account a large number of factors or conditions both internal and external to the part. Many of these, although evident in metal design problems, are habitually overlooked by the designer since their effects on metals are practically nil. The tendency to disregard these same factors in rubber design is the cause of considerable trouble.

A general outline of typical items which must be considered is shown in TABLE I. While this outline is by no means complete as far as every conceivable material property or performance condition encountered is concerned,

*Fig. 2—Examples illustrating the various classes of tolerances recommended for the metal components*



it covers most common problems and it will serve for purposes of general study.

Section I-A of this outline lists several of the most familiar functions for which structural rubber may be used. These application factors may be involved singly or in combination and are readily recognized, particularly insofar as theoretical treatment is concerned.

Section I-B shows various application types which are generally not considered as "structural" and are rarely approached from a theoretical analysis viewpoint. However, they occur frequently in combination with the nominal structural application factors and may have considerable influence on final design.

Section II lists factors or conditions external to the part which are considered as deteriorating or which will affect physical properties. Frequently these can be minimized by design treatment as well as material selection.

Section III lists those factors which express the principal basic material and chemical properties of a rubber compound. These cannot be modified by design, being fundamental material characteristics for each type of compound; however, their effects can be best utilized, or minimized if detrimental, by both theoretical and practical treatments. An examination of this outline, particularly by the less experienced, may readily reveal factors which are easily overlooked in various problems. (This outline, or one similar, will serve as a check list to prevent omission in design work.)

### Selecting Metal for Adhered Parts

METAL FACTORS: A wide range of steels, brasses, bronzes, and aluminum alloys permit application of rubber to metal structures. Some types of metal, however, such as zinc-base die castings, do not work satisfactorily not only because of adhesion variability, but also due to corrosion susceptibility and frequent lack of the required mechanical strength necessary for molding. Magnesium, a relatively new metal in this field, also presents problems which are being worked out in the pilot stage. Some of the synthetics and present production adhesion processes also are not compatible with certain metal alloys. It is therefore advisable to discuss new rubber-metal combinations with the rubber manufacturer, although production compatibility will be found to exist in a large percentage of typical cases.

Fabrication of the metal components or assembly of the finished part demands consideration of such elements as welding or brazing processes; integral bolts and nuts; machining for splines, press fits, etc. Welds must be sound and free from pits or inclusions and must be readily cleaned by sandblasting or pickling.

Welded joints and the component arrangement should be so accomplished that fluxes, oils, cleaning or plating solutions, or grit cleaning particles will not be trapped. This is particularly vital at or near the adhesion surfaces where such trapping may prevent proper cleaning or plating and further contaminate the treated surface by a bleeding action. Lap welds or similar types which use partial or interrupted beading are particularly bad in the respects mentioned. Copper furnace brazing generally produces a satisfactory joint since it is filled by the brazing material. The use of excess brazing metal at the joint, or flow around it, should be avoided since high copper alloys are not highly compatible with all adhesion processes. Welding processes are not recommended for attaching cured rubber-metal parts to mating parts or assemblies since heat produced may injure the rubber.

Integral bolts or nuts, as well as separate bolts or rivets, are the most common means of attachment. Of the integral bolt designs, the square shoulder peened type, *Fig.* 1, (*A*), is popularly used. The bolt is designed with a square tapered shoulder which permits a piloted prepositioning, and with sufficient shoulder length to provide material for upsetting or peening in the mating metal. The upsetting operation provides a tight joint which prevents escape of rubber at this point during molding. This is important since thread fouling and costly cleaning operations are avoided. The square shoulder prevents turning during assembly. This bolt type is currently used for thread sizes from 3/16 to 5/8-inch diameter and for metal thicknesses of 1/16 to 1/4-inch. Although standardization of peened bolt details and tolerances has not been adopted through the industry, the designation of this

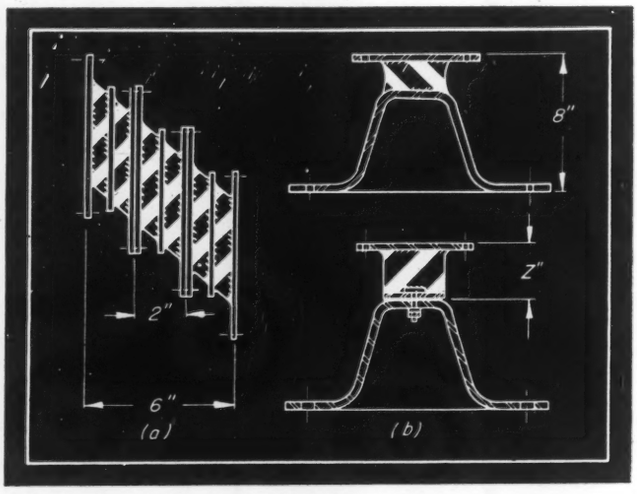



*Fig. 3—Reduction in unit part size can be effected through the adoption of segmental designs*

type of fastening as shown in *Fig.* 1, (*B*) is sufficient to show what is desired.

Attachments requiring threaded sections which must be incorporated into the metal components are shown in *Fig.* 1 (*C*), (*D*), (*E*), and (*F*). These are employed when integral bolts or separate nuts are not applicable. *Fig.* 1, (*C*) illustrates a tapped, drawn ferrule; (*D*) a projection-welded or furnace-brazed nut which also has a piloting collar for shear loads; (*E*) a design similar to (*D*) except for thread closure; and (*F*) an external projection welded nut. Type (*C*) is a low-cost element but has objectionable features due to stress concentrations and limited thread strength, particularly on thin metals or relatively small thread diameters. This type also requires insertion of a threaded pin in molding to keep out the rubber, the use of which represents a considerable cost element. Since rubber can be forced into the thread clearances during molding, a thread chasing operation in necessary. Type (*D*) is used where a flush nut, imbedded in the rubber, is necessary. It is a rugged type, although costly. The principal objections are high stress concentration, if

rubber sections are thin, and the necessity for protecting and cleaning threads. Type (*E*) is a more costly element than (*D*), but complete thread protection is provided, eliminating process protection costs. It is objectionable from a stress concentration viewpoint in some cases. Type (*F*) is used to provide thread closure and avoid stress concentration. It does take more space and is not structurally as safe as (*D*) or (*E*), although proper welding will produce surprising resistance to tension, shear, or bending forces. A 5,000-pound minimum tensile test is commonly met in 1-inch OD stock welded to 1/8-inch metal.

Close tolerances on metal details such as are required for precision pilots, press fits, splines, etc., are frequently difficult to maintain if these dimensions are "finished" prior to molding, particularly on fragile metals. One of the common metal design defects is the inability of metal components to resist the large crushing or bursting forces caused by the molding pressures involved, combined with the operational cost or impracticability of completely supporting the metal. Not only is maintenance of tolerance a question, but some materials do not have sufficient elasticity to permit deformations to "take up" metal tolerance and mold clearances, without breakage, to the point where the mold can provide full support.

Unit cavity rubber pressures of 5,000 psi are quite common and occasionally the figure may be as large as 10,000 psi. It is advisable to use the latter figure for a rough check on the effects of molding pressures on nonplanar metals. The importance of considering the effects of these forces on metals cannot be overemphasized.

The flash removal problem is also frequently such as to make a difficult operation (as in cleaning internal splines), or the metal finish may be damaged by brushing or scraping operations. To avoid the difficulties mentioned, the procedure of machining after molding is often used. While the sequence of the metal processes required is at the discretion of the rubber manufacturer, as to his doing precision machining before or after molding, the designer should consider the possibility of constructions which will avoid metal working after curing, since the processing and handling are costly and the special "know-how" for this type of operation is not widely found. This is particularly true at the present time since such operations, other than simple drilling, reaming, and broaching, have not been demanded extensively on rubber-metal parts. The rubber industry as a whole is therefore not set up, production-wise, to do metal working. Of necessity, such work is often done at considerable cost by other machining facilities. However, increasing requirements for close tolerance parts is currently fostering development of more refined molding methods, and installation of metal-machining equipment at the rubber facilities.

Metal tolerances are not only of importance to the user as they ultimately affect assembly or function, but are vital to proper molding. While this is an old subject, a review will serve to emphasize its importance. The metal inserts, as well as mold elements, must be held to reasonable limits to locate the metals properly (one with respect to another), to provide a tight cavity, prevent excessive metal distortion, and to maintain finished part tolerances.

The degree of overall metal accuracy required for molding purposes, particularly on large parts, is greater than that obtained on metal parts produced for general structural purposes. While it is difficult to state exact tolerances for general cases, the following general rules will apply:

1. Tolerances on overall dimensions, which must fit the mold cavity, should be held to close limits or on the minus side if broad limits are required in metal fabrication and are permissible in molding
2. Nonlocating clearance holes in the metal should be made larger than the entering core or pin and held to the plus side
3. Holes in metals through which mold cores or pins must pass to provide voids in the rubber, or which are used for assembly purposes, should be held to close limits or to the plus side if broad limits are required in metal fabrication and are permissible in molding
4. Channels or concavities in metals which fit over mold inserts are to be held as in (3)
5. All rigid bending radii which will mate with mold surfaces should be held to close limits on the radius of curvature if possible. If large limits are required, the radii should be held to the plus side

TABLE I

**Design Factors for Adhered Rubber-Metal Products**

| I—Functional Factors | II—Secondary or Hazard Factors | III—Inherent Rubber Property Factors |
|---|---|---|
| A. Structural use types<br>1. Vibration insulation or isolation<br>a. Mechanical (low frequency)<br>b. Audio (high frequency)<br>2. Shock or impact absorption<br>3. Vibration absorption or dampening<br>4. Resilient couplings<br>5. Resilient bushings or bearings | A. Heat sources or temperature changes | A. Modulus—tension, compression and shear<br>1. Static<br>2. Dynamic |
| | B. Rubber deteriorants<br>1. Oils, greases, solvents, etc.<br>2. Gases—oxygen, ozone, etc.<br>3. Rays—sunlight (ultra-violet), etc.<br>4. Cut, tear, or chipping-producing effects | B. Tensile and elongation |
| | | C. Bond stress limits |
| | | D. Fatigue characteristics<br>1. Static<br>2. Dynamic |
| | | E. Creep or set |
| | | F. Hysteresis |
| | | G. Abrasion resistance |
| | | H. Tear and cut growth resistance |
| | | I. Temperature effects on properties |
| | | J. Aging characteristics—resistance to heat, light, and atmospheric attack |
| | | K. Resistance to oils, greases, solvents, etc. |
| | | L. Resistance to unusual chemical deteriorants |
| B. Nonstructural use types<br>1. Sealing<br>a. Gaseous<br>b. Liquid<br>c. Solid (aggregates, etc.)<br>2. Protective covering<br>a. Physical (abrasion, scuffing, etc.)<br>b. Chemical<br>3. Frictional control<br>4. Electrical effects<br>a. Dielectric<br>b. Conducting | C. Metal deteriorants<br>1. Moisture<br>2. Corrosive fluids or electrolytes<br>3. Corrosive gases<br>4. Abrasives | |

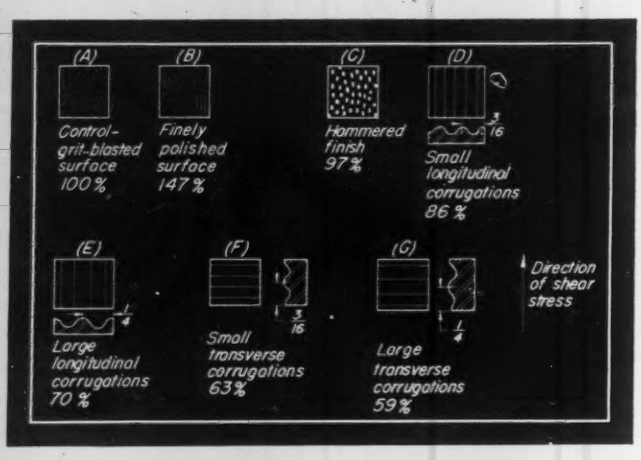



*Fig. 4—Effects of metal surface characteristics on ultimate shear strength of the bond*

for surfaces which are convex (with respect to the exterior surfaces of the molded part), and to the minus side for those which are concave

6. Dimensions covering hole diameters, hole or bolt spacings, pilots, or surfaces of metal used for metal location in the mold, must also have tolerances established on the basis of their effect on maximum accumulations possible on the molded part.

Average "close" general tolerances may be construed as $\pm 0.007$ to $\pm 0.010$ and broad tolerances as $+0, -1/32$ or $+0, -1/16$.

The foregoing points are illustrated in *Fig.* 2 (*A*) and (*B*). Item (1) is illustrated by dimensions *A* and *A'*, Item (2) by *B*, Item (3) by *C* and *C'*, Item (4) by *D*, and item (5) by $R_1$ and $R_2$. Item (6) can be readily understood since increased tolerances in the metal result in larger average mold clearances with the resulting possible shift of the metal with respect to the part margins or other metals in the part.

SIZE AND SHAPE FACTORS: Production limits must be recognized in designing a part as to its size, weight, and shape. For example it is generally unfavorable, from a quality and cost viewpoint, to design quantity production items with a net rubber section thickness in excess of 2 inches unless intermediate mold or metal component members provide excellent heat conductivity. The reason for such a limit is that the poor heat conductivity of rubber compounds results in an extremely long cure, with high burden costs, and may further cause a lack of uniformity of cure with resultant reduction in quality. Individual problems may require exception to the rule, particularly on small production items, but they should be considered only after proper consultation. Length and width factors are much more expansive, and typical large items processed on a production basis may run up to 24 inches x 24 inches.

A basic cost principle in economical quantity production is that the minimum amount of metal necessary to the final part assembly be brought through the rubber manufacturing processes even though additional subassemblies may be required. The design of parts involving use of a great proportion of metal with respect to the rubber, so as to produce "unit" constructions, increases handling costs and results in a lower quantity yield from various high-burden processing equipment. Unavoidable additional operations may also be involved for protection in process or flash-removal operations.

Parts should be designed so that the major attachment bases will be principally on the base assembly unit rather than on the rubber-metal components. A part may also be broken up into several components and manufactured and assembled more economically as compared to a single large section.

Examples of treatment of actual problems are shown in *Fig.* 3. Detail (*A*) shows the typical treatment for multi-section shear sandwiches when large total thickness is required to produce large deflections. Detail (*B*) shows a redesign of a part to reduce the amount of metal to be processed through the rubber plant.

In general, part weights up to approximately fifteen pounds are readily handled; between fifteen and twenty-five pounds, handling becomes more difficult; and in excess of twenty-five pounds special handling or processing is a practical must which, of course, increases costs out of proportion to the increased weight.

ADHESION CONSIDERATIONS: One of the factors which is subject to considerable misunderstanding and controversy is that of adhesion. Strictly speaking, low ultimate bond stress values are not the underlying cause in most so-called adhesion failures. An examination, by the author, of many failed parts and their operating history indicates that factors frequently contributing are: Stress

TABLE II

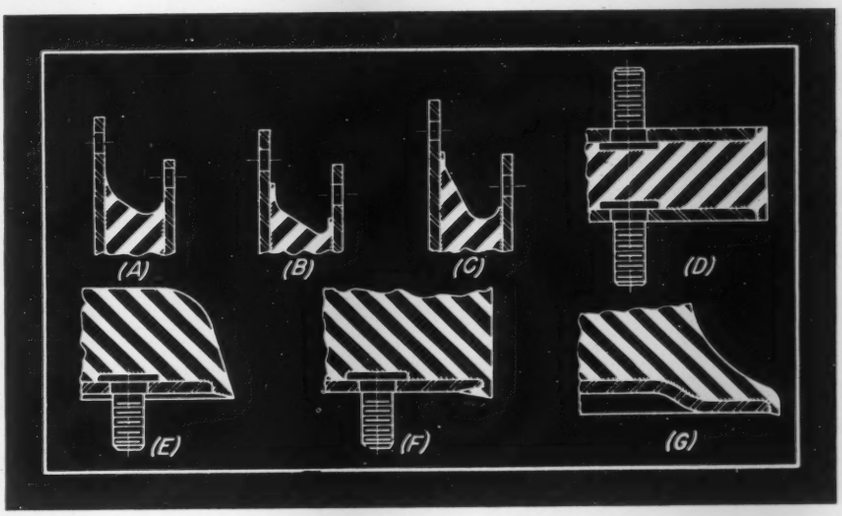
**Typical Minimum Fillet Practices**

| | Application | Service Conditions | Principal Type of Bond Loading | Fillet Type* |
|---|---|---|---|---|
| 1. | Interior industrial and automotive mountings | Normal atmosphere, light oil vapors, low corrosive hazard | Compression with average static and dynamic stresses | None |
| 2. | Interior industrial and automotive mountings | Normal atmosphere, light oil vapors, low corrosive hazard | Shear, average stresses | (A)† or (D) |
| 3. | Interior industrial and automotive mountings | Same as 1 and 2 plus mild corrosive hazards | Compression or shear, average stresses | (A)† or (D) |
| 4. | Interior industrial and automotive mountings | Corrosive hazards present—severe | Compression or shear, average stresses | (B) |
| 5. | Automotive chassis, railroads, exterior industrials, chemical processing equipment | Severe atmospheric moisture or corrosive condition, or liquid immersion with seal required around part | Compression or shear, average to severe stresses | (E) or (F) |
| 6. | Automotive chassis, railroads exterior industrials, chemical processing equipment | Severe corrosion or stress conditions, or both | Compression or shear | (G) |
| 7. | I.D.—O.D.—Adhered Bushings | Mild corrosive | Average shear, compression, and induced tension | (A) or (B) |
| 8. | I.D.—O.D.—Adhered Bushings | Mild to severe corrosive | Severe shear or compression and induced tension | (G) |

*See *Fig. 5*

†Fillet used on edges normal to direction of shear force

*Fig. 5—Rubber fillet types of adhered rubber-metal parts*




concentrations from poor metal or rubber design; metallic corrosion at the bonding layer; mechanical injury; deterioration of the rubber by various light rays, gases, solvents, or oils; and static or dynamic fatigue to the rubber, although casual examination may indicate otherwise. Failure often starts from one or more of these causes and then a gradual flex-tearing and bond deterioration progresses along the adhesion face. Assuming that the best material has been selected for a given job, and proper design analysis has been made, some corrective factors available to designer are: (1) Use of metal having proper adhesion face characteristics and freedom from sharp edges, burrs, or other stress raisers; and (2) use of fillets, and precompression where practicable, to reduce stress concentration at the rubber margins and to resist various corrosion hazards.

Characteristics of the adhesion surfaces have important effects on both processing and performance. Regardless of the process used for adhesion, uniformity of treatment is paramount and this requires relatively smooth, continuous surfaces for this purpose. This same type of surface also produces high bond strengths for the direct adhesion of flexible rubber to metal. This is contrary to the common assumption that knurled patterns, corrugations, serrations, undercuts, holes, etc., will improve bond performance. This erroneous belief stems from three sources: (1) The basic mechanical interlock and increased area concepts; (2) the early adhesion practices that involved the use of a thick layer of hard rubber between the flexible rubber and the metal base, and which was adhered in part by mechanical anchoring of the type mentioned in (1) and; (3) the occasional acceptable use of ribbing or deep knurling on parts subject to severe corrosion and on which frictional adhesion can prevent sudden failure. Pressure rollers used in chemical processes or marine pump impellers are examples of the latter.

## Effect of Surface on Bond Strength

In *Fig.* 4 are shown some results demonstrating these points by comparing surface effects on ultimate bond strength through use of various surface treatments. The same metal, adhesion method, and compound were used in all tests. Values shown are the relative average unit shear bond loading determined by using the stressed area as that projected on a plane parallel to the face of the metal. The shear force was applied in the direction shown by the arrow. The relative percentage bond strength rating of each type surface is shown below each figure. These data demonstrate quite dramatically the futility of using expensive corrugating operations to improve bond strength. Other tests utilizing sharp-edged sawtooth type of serrations for the bonding surface have shown even more drastic reductions in bond strength, as may be expected. While the specific bond values will vary with compound type and shape factors, these tests nevertheless serve to indicate the general effect of surface roughening or ribbing to increase bond strength.

Bond strength can be improved as indicated by using finely polished metal surfaces but such refinements are not necessary to obtain satisfactory results for general application. Finishes produced by smooth rolling, drawing, machining, and grinding operations are satisfactory provided that imbedded oxide or other slag inclusions, pits, folds, seams, burrs, etc., are avoided. Smooth cast or forged surfaces are also acceptable provided that protruding sprues or similar projections, flash fins, pits or porosity, and other surface defects are not present. A sandblasting or pickling operation is used to remove scale or oxide layers prior to adhesion processing. Castings or forgings may also require machining on edges or surfaces involved in positioning or cavity sealing at molding operations.

In *Fig.* 5 are shown various types of fillets commonly used to increase bond life. Detail (*A*) illustrates the familiar circular segment. This will produce protection from mold fatigue and corrosion effects and is most easily made as to economy of equipment and assembly space. The angular or buttress design of the rubber at the ends of shear sandwiches, such as shown in (*A*), (*B*), and (*C*), also serve to reduce the induced tensile forces at these sections as well as to increase stability. Detail (*B*) illustrates a fillet which will produce normal fatigue protection with increased protection against deteriorants which may migrate through the "toe" or tangent section of the common fillet. This fillet also offers resistance to mechanical action or injury from flying debris which may crush through the toe sections. Conditions involving corrosion and debris are commonly involved on material-handling devices, railroad truck applications, truck and automotive chassis, etc.

Details (*C*) and (*D*) show further extensions of these principles. Detail (*C*) represents a special type combining bond protection and stress relief, with a special stress relief element required to reduce detrimental effects in the body section. Detail (*D*) accomplishes part of the fillet effect by metal modification. Detail (*D*) is generally costly to incorporate as based on metal manufacture, but may be most economical where operational factors—corrosion and fatigue—are severe.

Details (*E*) and (*F*), which fall in the class of "beads"

are actually modifications of filleting and sealing devices. These permit complete closure of the metal insert and mating attaching surfaces.

Detail (*G*), which is an extension of (*B*) or (*C*), is a more specialized element, and is used only under conditions of extreme stress concentration or bond hazards. This particular element is incorporated into at least one patented design. It is quite effective on parts where high radial compression, circumferential shear, and induced tension forces are encountered along with severe weathering and corrosion hazards on such applications as tractor track bushings.

As to the proportion of the rubber fillets, in general a larger size of fillet is used than those applying to stress relief for a similar mass and shape of highly stressed metal. The exact size is still determined by experience since little theoretical work has been done on fillet behavior.

Several service conditions are outlined in TABLE II showing the recommended fillet treatment. This may serve as a guide in selection. The type numbers shown refer to *Fig.* 5. It should be borne in mind that, regardless of any minimum recommendation, if fillets can be incorporated with little or no cost penalty, they should be employed in the same generous manner as similar protective elements are applied to highly stressed metal parts.

LOAD-DEFLECTION TOLERANCES: Various classes of rate limits commonly used for production of *natural rubber* are typified as follows:

1. Thin parts (less than ½-inch) having special control on metal component dimensions, part thickness, and rubber modulus; or thick parts (1 inch and up) with commercial limits on metal component and special control on part thickness and rubber modulus, ±7½ per cent
2. Thin parts with commercial limits on metal dimensions or thick parts with large metal tolerances combined with special control on part thickness and rubber modulus, ±10 per cent
3. General parts subject to commercial limits on metal dimensions and standard compound control, ±15 per cent and up.

Parts which must be held within rate limits of ±10 per cent or less are generally so specified in the drawing according to the rates or load-deflection tests required. Parts in the ±15 per cent class can generally be specified by Shore Durometer, Type A, hardness with limits of ±3 points.

Synthetics will generally require rate limits about 5 per cent greater than for natural rubber, or Shore "A" Durometer limits of ±5 points.

Discretion must be used in specifying close rate limits since a premium will be paid for selected metal dimensions if required, special control procedures in processing the rubber, and testing of the finished parts particularly since the latter must frequently be done on a 100 per cent basis.

Parts used for shock loads, variable cycles, etc., where maintenance of a certain natural period is not involved, can be specified according to stock hardness only.

Systems which have an insulation ratio (forced frequency divided by natural frequency) above 2½ or 3 generally can use parts subject to normal durometer hardness controls, since the natural frequency is proportional to the square root of the rate, and a rate variation of ±15 per cent will produce a natural frequency variation of only ±7 per cent. Installations which have a low insulation ratio and involve occasional idling at speeds near or below the natural frequency are more critical and do justify maintenance of rate limits in the ±7½ per cent to ±10 per cent class. Aircraft engine mountings and other variable-speed machine suspensions fall into this class. Parts which are to be effective at particular frequencies, as is required in tuned absorbors, are also held to rate limits of ±7½ per cent to ±10 per cent.

Miscellaneous variable-speed and load motors or machines such as automotive engines, blowers, compressors, or pumps are, most frequently, not critically mounted. The ±15 per cent rate tolerance as indicated by a ±3-point Shore "A" hardness and ±5 per cent limits covering dimensional modulus variations are generally satisfactory for such installations.

FINISHED PART TOLERANCES: It is a common error in the designing of rubber products either to specify molding tolerances which are not easily obtainable on a production basis or necessary to part operation, or to show none and assume that the parts will be made to commercial limits procurable from common metal machining operations. The designer is also prone to forget that tolerances existing in metal components are reflected in the finished part since locating of the metal in the mold is accomplished with fixed pins, cavities, etc. The metal parts can therefore float within the accumulated limits of component tolerances and processing equipment tolerances. Metal distortion effects are also a part of this problem.

## Protecting Rubber Surfaces

PROTECTIVE COATINGS FOR RUBBER: Flexible protective coatings are applied to structural rubber parts as a means of reducing ill effects of common fluids, and occasionally gases and light rays. The most common uses of these coatings are for oil, grease or solvent protection of natural rubber or GR-S products. These are, basically, cements or lacquers made from elastomers such as Neoprene or Buna "N" which have preferred characteristics insofar as resistance to the fluids mentioned is concerned.

In some cases it is the practice to apply protective coatings to parts at installation as well as at subsequent maintenance. The coating may not be necessary for protecting the rubber, but may represent a general application, such as used in painting machine assemblies. Caution should be observed to avoid use of enamels or paints containing driers (oxidiers) or other chemicals which may be injurious to rubber. The use of common oil paints has occasionally caused serious trouble from accelerated oxidation effects.

Complete coverage of all the basic practical aspects of structural rubber design would require considerable space to present completely and a great number of elements involved in highly specialized products remain untouched. It is hoped, however, that sufficient information has been given to explain some of the practices which are not commonly understood and to aid in recognition of elemental problems in this field. Emphasis must also be placed on the recommendation that the designer should check application of new materials or design concepts with the rubber manufacturer to assure proper understanding and the best problem solutions.

# Electronics Aids Hydraulic Circuit Analysis

*Fig. 1—Above—Designed for indicating and recording pressure fluctuations in hydraulic systems, the Hydrauliscope can point the way to improved hydraulic circuit design*

HOW the inherent inertia of conventional pressure gages prevents them from responding to the peak pressures and surges occurring in modern high-pressure hydraulic systems was dramatically illustrated by a recent case. Repeated failure of a flexible hose in an aircraft hydraulic system kept occurring while the gage indicated a peak pressure which was only a small percentage of the bursting pressure for this type of hose.

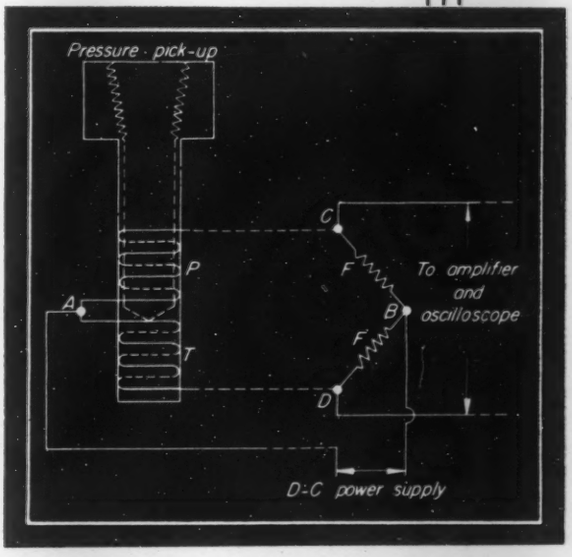
This and similar experiences prompted engineers of the Aeroquip Corp. of Jackson, Mich., to develop a more responsive pressure-measuring device, *Fig.* 1, which would indicate and record pressures of only a fraction of a second duration. When applied to the hydraulic system just mentioned, the new device demonstrated that momentary peak pressures sufficient to rupture the hose were in fact occurring. Furthermore, analysis of the pressure changes pointed the way to improved design which would eliminate the high-pressure surges that were causing the trouble.

### Eliminates Need for Special Skill

Known as the Hydrauliscope, the unit is a portable electronic analyzer in which all of the elements required to transform pressure impulses at the pickup into indications on a cathode-ray tube are integral. Whereas a conventional oscilloscope needs several accessories, requiring the services of an "expert," the Hydrauliscope can be operated by persons with no special knowledge of electronics.

Basis for the operation of the unit is the well-known Wheatstone bridge circuit, *Fig.* 2. The pressure pick-up has a hollow thin-walled section connected to the hydraulic line at the point where pressure behavior is to be studied. Resistance wire, *P*, wound circumferentially on the pressure-sensitive tube stretches due to the increase in length and the decrease in cross sec-

*Fig. 2—Below—How the pressure pickup element is incorporated in the Wheatstone bridge circuit. Fixed resistances, F, are incorporated in the Hydrauliscope*



tion of the wire. Inasmuch as resistance is affected also by temperature changes, a compensating coil, *T*, having resistance equal to that of *P* (7500 ohms), is wound on the solid section of the pick-up. Temperature changes affect coils *P* and *T* equally (due to change in specific resistance of the wire material and to thermal expansion of the tube material), hence the division of current between the two coils remains equal and the voltage difference between *C* and *D* remains unaffected by temperature.

When the resistance of coil *P* increases as a result of the application of pressure at the pick-up element, current flow in branch *ACB* of the bridge circuit decreases, voltage drop in leg *CB* decreases, and the voltage at *C* becomes greater than at *D*. The 35,000-ohm resistances, *F*, which are located in the Hydrauliscope proper, are not changed, hence the changes in voltage between points *C* and *D* are proportional to the change in current which, in turn, depends on the stretching of the tubular part of the pressure pick-up.

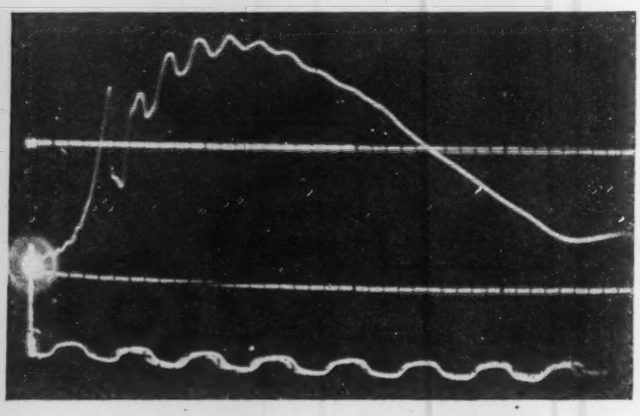


*Fig. 3—Typical pressure record from Hydrauliscope*

Expansion of the tube is slight—only 0.0003-inch at maximum pressure. This represents an increase in resistance of approximately 13 ohms in the 7500-ohm coil. Such slight movement minimizes inertia effects so that the response of the pick-up accurately reflects the pressure changes regardless of rate and frequency, but the resulting voltage differentials between *C* and *D* are so small (approximately 61 millivolts or 0.061 volts) as to render necessary considerable amplification for use with the cathode-ray oscilloscope. However, the resistance of the coils is considerably higher than that of the conventional strain gages in common use, resulting in a relatively higher output and necessitating a correspondingly smaller amplification. Three ranges of pick-ups are normally used: Low pressure (vacuum to 500 psi); 0 to 3000 psi; and 0 to 5000 psi. Each pick-up can be used for shock pressures up to 1½ times and occasional surges up to 2½ times the maximum nominal pressures.

A regulated d-c voltage, obtained from power-supply components incorporated within the Hydrauliscope, is applied to the bridge circuit as shown in *Fig.* 2, the output of the bridge then going through an amplifier and a synchronizer element. The amplified voltage is applied on the appropriate plates of the cathode-ray oscilloscope, causing the ray or beam of electrons to be deflected vertically in proportion to the pressure change. A sweep-control unit of the conventional type furnishes the necessary voltage to the other plates to give the desired horizontal movement to the beam.

In order to permit indication of steady pressures and calibration by static testers, the amplifier is of the dc-coupled type. To offset the tendency to drift which is chacteristic of dc-coupled amplifiers, additional regulating circuits are incorporated to provide the necessary stability, which increases the number of tubes to sixteen compared with the six or seven used in a conventional oscilloscope.

Representative of the type of information which can be obtained with the Hydrauliscope is the record shown in *Fig.* 3. The curve, which was made with the aid of a photographic attachment, shows the pressure variations in the cylinder of a hydraulic lift truck when a full load is dropped from full height and stopped just off the floor. The horizontal sweep was started just as the valve handle reached the neutral or shut-off position. At the bottom of the record is a timing wave of 100 cycles per second, the eight cycles of which indicate 0.08-second total duration of action shown. Pressure reference lines traced at zero and at 600 psi static pressure establish the scale of the graph, from which the maximum pressure is found to be 1050 psi.

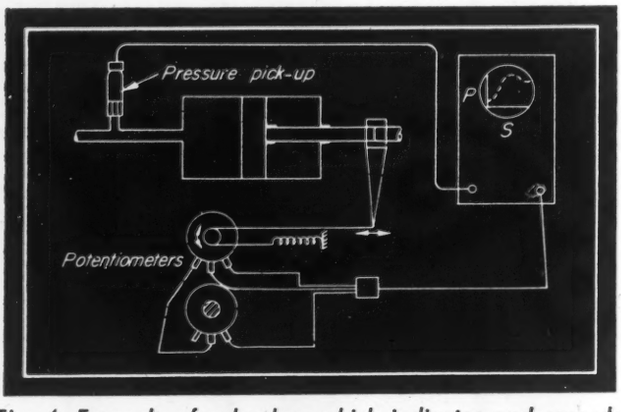
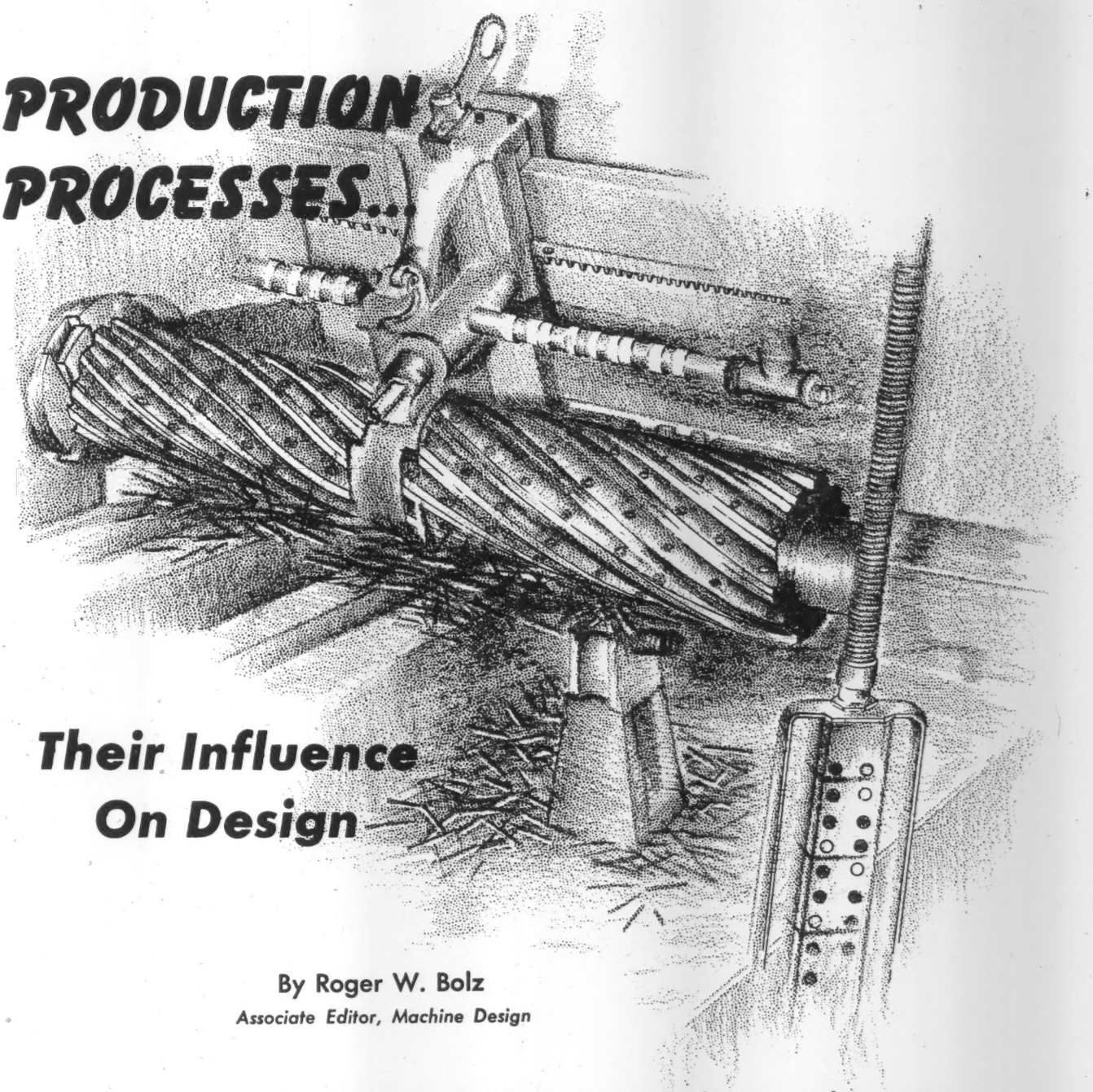



*Fig. 4—Example of a hookup which indicates and records pressure as a function of piston or valve travel*

When it is desired to trace a pressure curve against the mechanical motion of a piston rod or valve stem, instead of against time, an arrangement such as that shown in *Fig.* 4 can be used. Two potentiometers are mounted adjacent to the valve, piston or mechanism whose motion is to be translated to movement of the beam on the horizontal axis of the cathode-ray tube. One potentiometer is connected mechanically through suitable lever or pulley and cable combinations so that the motion—rotary or reciprocating—is converted to a 270-degree rotary movement of the potentiometer shaft. A potentiometer having linear characteristics in the middle 270 degrees of its adjustment range is used in order to obtain linear relation of beam movement with respect to piston or valve movement. The second potentiometer provides adjustment for the length of travel of the beam on the screen of the oscilloscope.

# PRODUCTION PROCESSES...



# Their Influence On Design

By Roger W. Bolz

*Associate Editor, Machine Design*

## Part XXI–Production Milling, General Considerations

OF ALL the production methods for metal removal, with the possible exception of turning, milling is undoubtedly the most widely used. Well suited and readily adapted to the economical production of any quantity from a few parts to a multitude, the almost unlimited versatility of the milling process today commands the attention and serious consideration of designers from all walks of engineering concerned with the manufacture of machines or mechanisms.

Parts which fall within the scope of production milling may range from a coupling shaft for a tiny mechanism, *Fig.* 1, to massive locomotive main rods, *Fig.* 2. Finished surfaces likewise may range from simple, plain geometric shapes to extremely complex shapes and irregular forms. It should be kept in mind, however, in the design of parts which are to be produced in large quantities to close tolerances, that where surfaces to be produced can be adapted for broaching, as discussed in Part I of this series, production speed will usually be higher and cost per piece lower. Otherwise, where repetitive production machining is concerned, milling provides an almost universal method of creating accurate parts for interchangeable manufacture.

Milling of metal is performed in a multitude of ways on a wide variety of machines—standard and special—with an equally wide diversity of cutters, *Fig.* 3. Inserted or integral teeth on the cylindrical body of the milling cutter remove excess metal in small individual chips as a portion of a part is passed through the path of the cutter teeth. In the majority of cases, the surfaces generated in milling may be classified by the basic method used. Those generated in *peripheral* milling are the

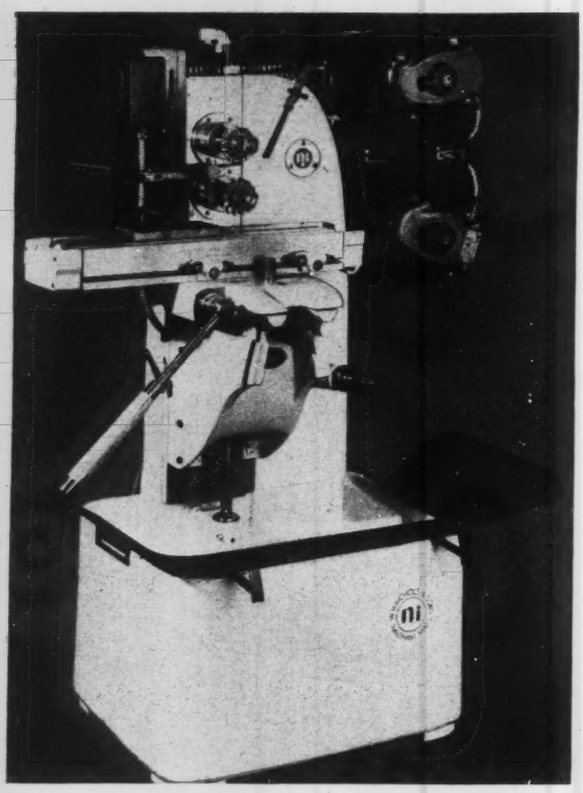


*Fig. 1—Above—Sliding-head hand miller set up for producing a special short coupling shaft*

result of cutter rotation about an axis parallel to the finished surface while those generated in *face* milling result from cutter rotation about an axis perpendicular to the finished surface, *Fig.* 4. As shown, peripheral milling operations can be performed in what is known as "conventional" or "up" milling as well as "climb" or "down" milling while in face milling these two methods are usually combined.

Conventional milling methods are widely employed in manufacture owing to the fact that the natural separating forces created between the work and cutter tend to minimize rigidity, accuracy and safety demands. Climb milling, on the other hand, requires well-built machines without backlash in the table feed screw mechanism to assure accurate results and safe operation. Much attention, however, has been given climb milling in recent years and with improved machines now available this method is gaining wide acceptance. It makes possible a considerably improved surface finish over that produced with conventional milling, milled surfaces being relatively free from cutter marks and easy to polish. In some cases climb milling simplifies fixture design and makes practical the holding of slender and intricate parts. Power consumption is somewhat

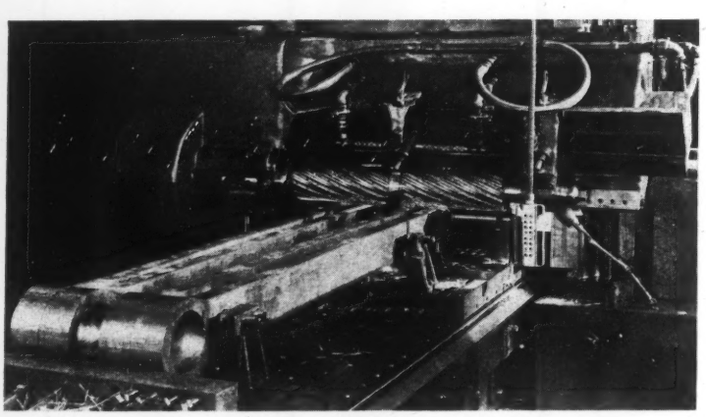
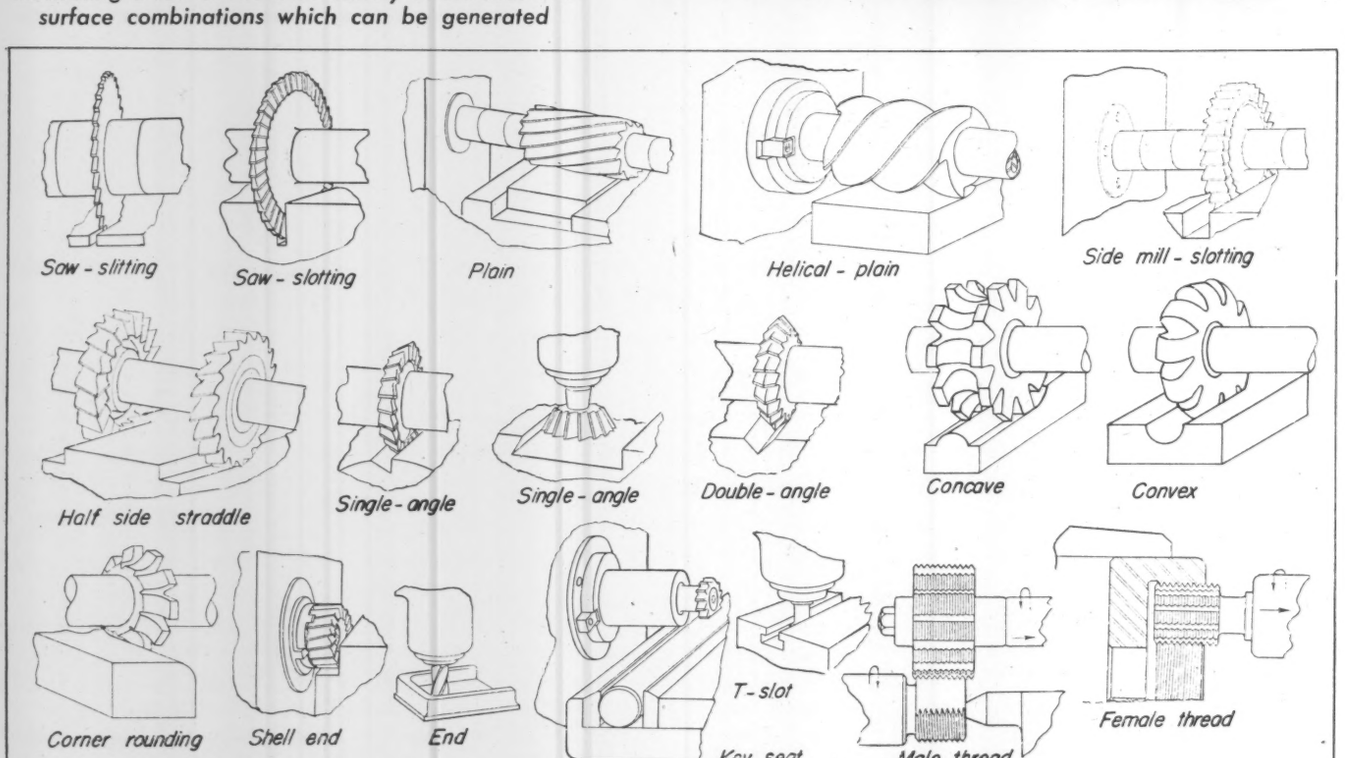


*Fig. 2—Right—Horizontal-spindle, inclined-rail milling machine performing the edging operation on a pair of locomotive main rods*

*Fig. 3—Below—Basic milling operations and cutters, illustrating a few of the wide variety of surfaces and surface combinations which can be generated*



lower, permitting removal of more metal, and considerably increased cutting speeds and feeds are practical owing to thicker chips and lack of lifting forces on the workpiece.

Undoubtedly the most superior surface finish is obtained with face milling, especially where high-speed milling with carbides is concerned. In addition, when compared with other types of cutters, face mills permit the greatest possible feeds and speeds commensurate with maximum cutter life and, since these mills also cost the least to manufacture and maintain, they afford the maximum in production at lowest cost per part.

In the many cases, however, where surfaces to be machined prove to be other than the straight-line simple geometric forms within the scope of standard cutters, special form mills of almost unlimited variety can be utilized, *Fig.* 5. Form milling cutters of such complexity are either of the form-relieved or shape-profiled variety; the former must of necessity be made of high-speed steels with accurately generated form-relieved teeth while the latter are made with high-speed steel or carbide inserts which are formed to the desired shape in a contour grinder. Sharpening problems with the shape-profiled cutters are not as great as with form-relieved mills but naturally somewhat more so than with plain standard types. Shape-profiled cutters, however, present the opportunity for economical production of relatively simple geometric forms, especially with carbide-tipped blades which can operate at extremely high speeds and feeds. Carbide blades are usually used with a negative rake for cutting the tough ferrous metals although positive-rake cutters with only 0.015 to 0.020-inch of negative rake length at the cutting edge are used successfully and are said to consume less power. For cast iron and the nonferrous alloys the rake angle for carbides usually varies from 0 to 10 degrees positive.

### Cutter Design is Important

Part design, as a rule, dictates to a great extent the general type of cutter which is most suitable. Production quality, costs, available production equipment, etc., control the final selection. Where processing costs are found to be excessive, redesign to utilize less expensive cutters or to improve metal removal efficiency is sometimes necessary. An idea as to the range of special cutter possibilities can be gained from the sketches shown in *Fig.* 6 Also apparent are some of the relative advantages and limitations of solid high-speed steel, inserted-blade and carbide-tipped cutters with respect to design of parts to be milled.

Much is yet to be learned in the field of milling relative to optimum cutter speeds and feeds. Actual production work with lightweight nonferrous materials during recent years show conclusively that no upper limit to peripheral speeds has yet been found. Practical machine and spindle limitations set the limits today since gain in speed without a corresponding gain in feed would be of little advantage. Numerous careful investigations seem to indicate, however, that with low-carbon steels, stainless steels and wrought iron, peripheral speeds in excess of 1000 surface feet per minute and probably 500 for high-carbon steels and alloy steels even in heat-treated state would not be advantageous.

To provide at a glance a general impression of present-day overall practice in production milling, the data in TABLE I have been compiled. Necessarily these data are not specific but rather indicative of what can be expected. Naturally, optimum efficiency of metal removal depends

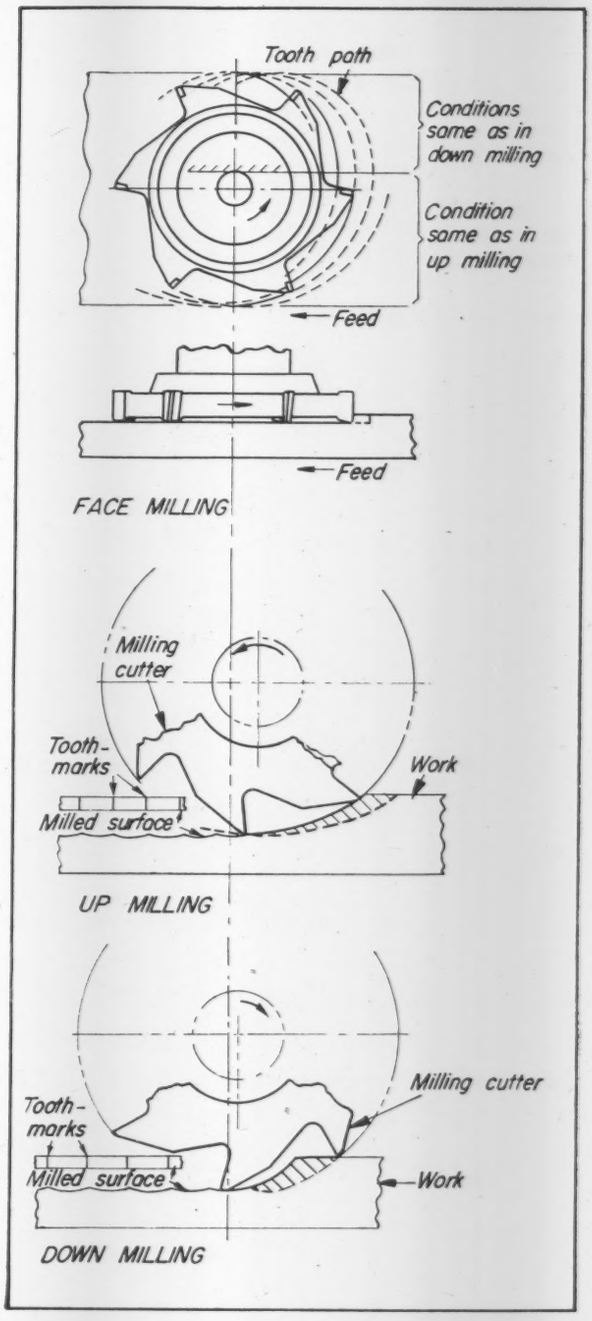
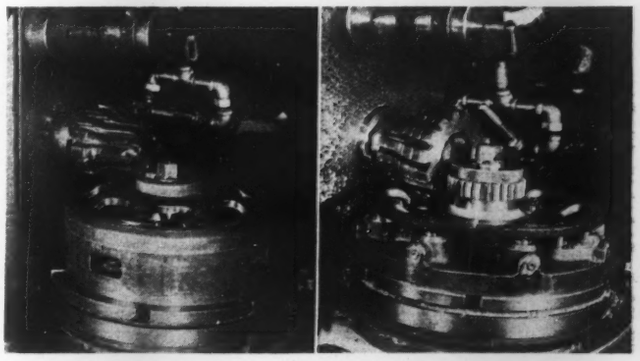



*Fig. 4—Above—Views showing the type of surfaces generated in both peripheral and face milling*

*Fig. 5—Below—Curved surfaces of this housing require a special form-relieved milling cutter*



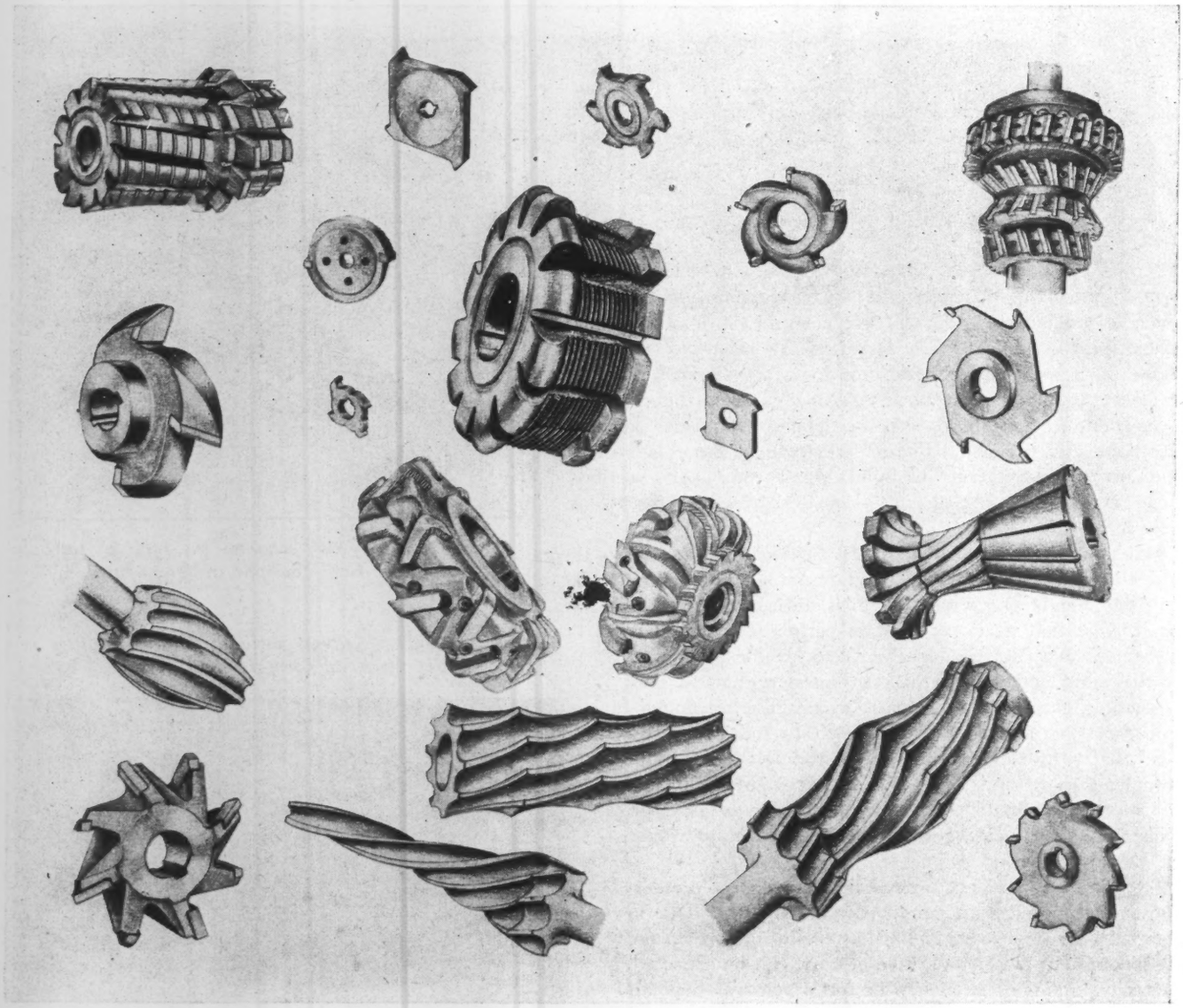
greatly upon the machine capacity, cutter design, part design, fixture design, etc.

Cutter design, to achieve the advantages accruing to high-speed milling which can be seen readily from TABLE I, inevitably must utilize carbides for the cutting teeth. Whereas, in general practice with high-speed steel mills and standard machines, not more than 25 cubic inches of cast iron or 12.5 cubic inches of steel could be removed per minute, the use of carbide-tipped mills make possible the removal of 150 cubic inches of cast iron, 75 cubic inches of steel and in aluminum or magnesium alloys as high as 500 cubic inches per minute. The latter carbide work, however, requires a high powered miller such as the present day 50-hp machines which have on occasion removed as much as 300 cubic inches of cast iron and 200 of steel for short periods. Thus it is surmised that "machinability" or efficiency of metal removal may be largely influenced, perhaps completely determined by the cutting materials and techniques utilized!

The obvious advantages of high-speed carbide milling, again, are subject to limitations. Naturally, the cutter design limitations mentioned previously come into play, and where part contours cannot be simplified or partially altered to permit using plain or shape-profiled carbide mills, special mills are necessary even though these may be more expensive in first cost and reconditioning as well as lower in production speed. Also, if the part is thin or frail, it will not withstand the strains of a heavy carbide cut and as a result high speeds and feeds cannot be used. Proper design of holding fixtures will, in many cases, permit the high-speed milling of small or light parts. However, additional ribbing or buttressing to "beef" up a part to resist heavy cuts often involves a relatively small increase in material costs which can be readily offset by drastic reduction in processing costs.

Of primary importance along with massive, well-built fixtures is the necessity of designing such fixtures to require the very minimum in loading time. Little savings can accrue from a drastic speedup in machining time if handling time is out of proportion, *Fig.* 7. Consequently, parts which are complicated and difficult to handle or require excessively intricate fixtures may prove worthy of consideration for redesign in view of the foregoing. Another point of interest is in regard to machine spindles

*Fig. 6—Below—A selection showing a few of the wide variety of special cutters used in production milling*



—a horizontal spindle in the majority of cases is found preferable for heavy milling cuts, *Fig.* 8. Naturally some operations require and can be accomplished best by a vertical spindle and cutter, but a small rate of metal removal and a less satisfactory surface finish are the usual penalties unless the machine has the required rigidity for good performance.

TYPES OF MACHINES AND THEIR SALIENT CHARACTERISTICS: An interesting fact which is undoubtedly well known and recognized is the wide diversity of milling machines which can be called into play by the designer. Actually, with the exception of extremely specialized applications, practically any reasonable milling operation can be handled economically and rapidly when due consideration is paid the selection of the right machine for

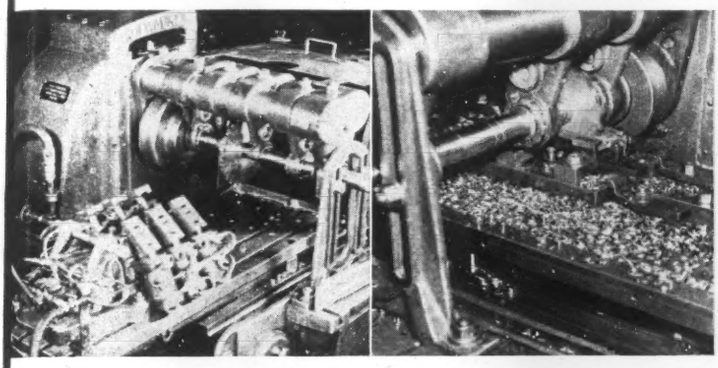
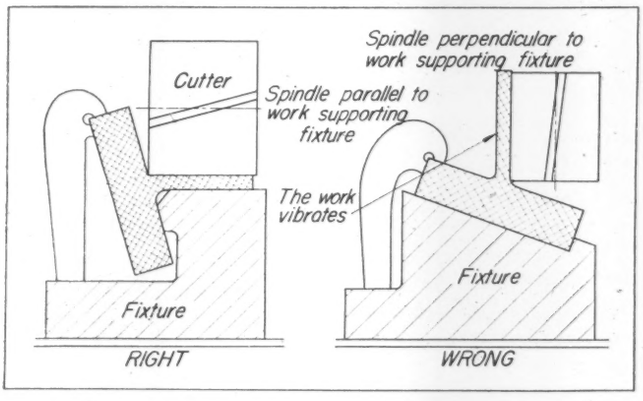


*Fig. 7—Above—SAE 4340 wing hinge forging and fixture used with 0.5-ipm feed, right, and special hydraulic fixture for carbide tipped cutter, left, allowing 13-ipm feed and reducing handling from 5 minutes to 20 seconds. Overall time was reduced from 35 minutes to 55 seconds*

*Fig. 8—Below—Horizontal-spindles, where cutter load is against table, provide best results and least fixture problems*




the job at hand. However, where quantities to be processed are only nominal and purchase of the right machine cannot be justified costwise, knowledge of the capabilities and limitations of the machines at hand will enable the engineering of usually reasonable and economically satisfactory designs.

*Column and Knee Millers*: Primarily intended for general-purpose work in low and medium production, column and knee millers usually fall into several groups—plain or universal with horizontal spindles, vertical with vertical spindles, and bench type universals. Plain types permit longitudinal, transverse and vertical table motion, *Fig.* 9,

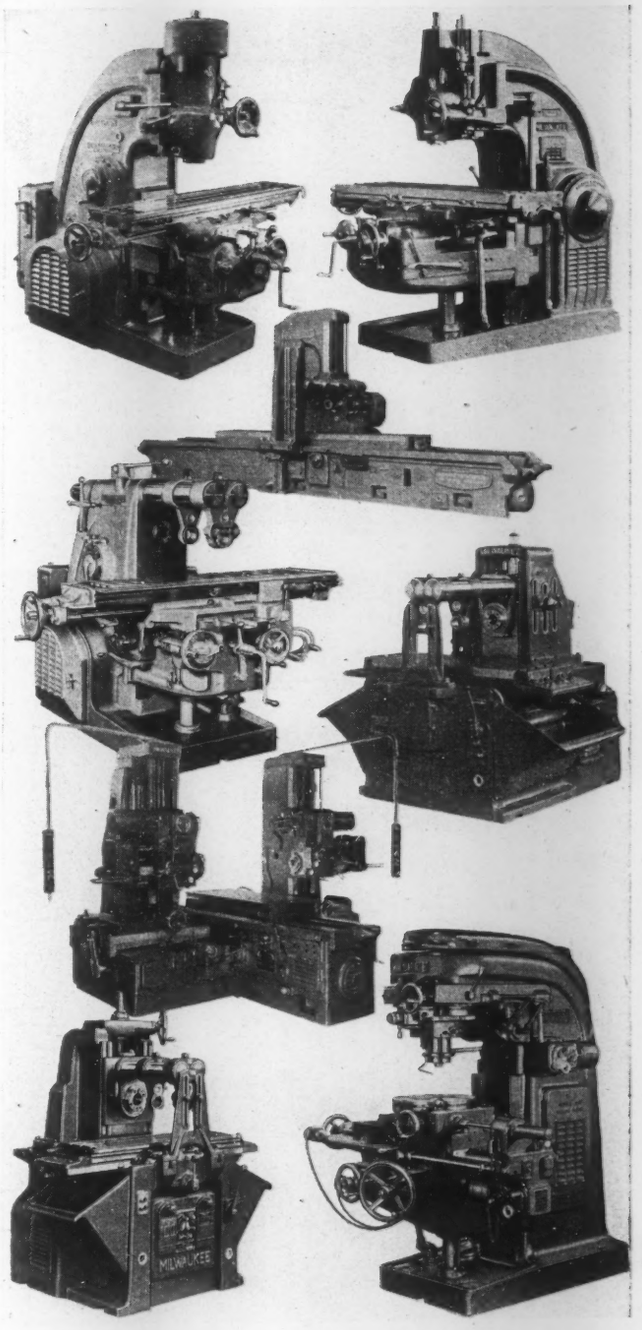


*Fig. 9—Standard milling machines, of which this is a representative group, provide wide possibilities*

while universal types permit swiveling of the table in addition. Vertical table motion is attained through actuating either the table or cutting head unit. Horizontal spindles have rotating motion only while vertical spindles need not be fixed but can have hand or power feed. Vertical machines are used on face and end mill work and frequently have rotary tables for generating cylindrical surfaces. Bench type universals incorporate all the features of larger floor models, *Fig.* 10, but of course are limited to somewhat smaller parts where power demand does not exceed one horsepower. For production work, models are available with automatic table feed, *Fig.* 11, making it possible to mass produce small, accurate parts with minimum cost in machine and tooling.

*Hand Millers:* These machines are usually of the col-

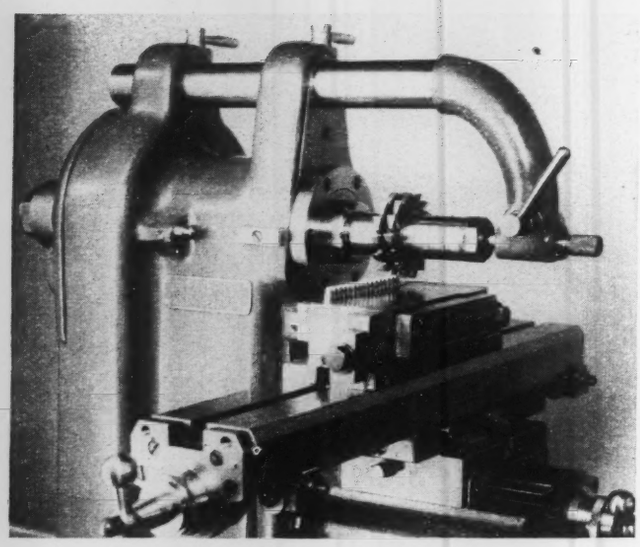
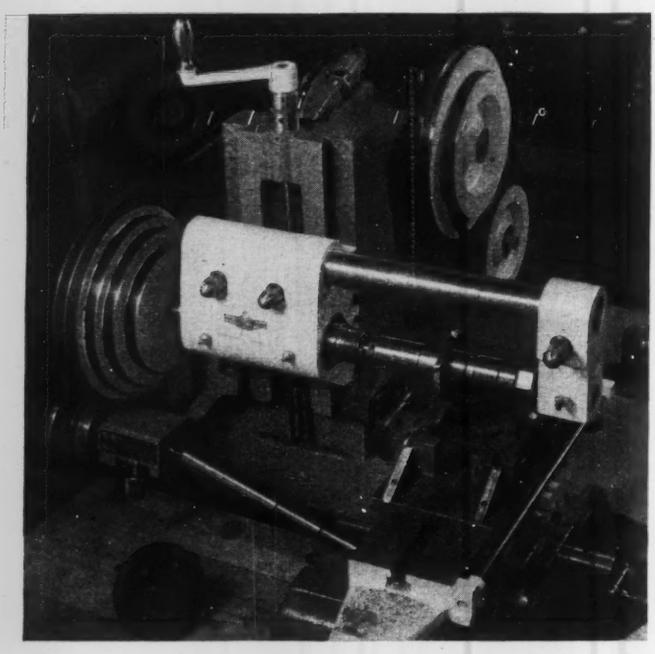


*Fig. 10—Above—Standard bench type universal, equipped with a special fixture for milling gun barrel rifling cutters*

*Fig. 11—Below—Automatic power feed bench millers provide a highly flexible production machine*



umn and knee type with one or two spindles. The dual-spindle machine can have the spindle spacing adjusted to suit, *Fig.* 1. Table movements are hand controlled, providing high sensitivity which makes them ideal for delicate operations on small parts. Use is confined principally to the manufacture of small quantities of light work.

*Fixed-Bed or Manufacturing Millers:* Manufacturing type machines, *Fig.* 9, as can be surmised, are designed primarily with an eye toward efficient production operations rather than overall general utility. They provide an extremely rigid construction and simple automatic operational characteristics for maximum economy in the mass production of small and medium-size parts. Available in either simplex or duplex models, the simplex miller has but one column on which the vertically adjustable spindle housing is mounted while the duplex has two opposed columns with vertically adjustable spindles. As indicated, fixed beds provide controlled longitudinal travel only.

*Planer Type Millers:* The common makes of planer type millers are primarily intended for producing one or more long straight surfaces on large, heavy machine parts, *Fig.* 12, or on a group of parts arranged in a series of fixtures on the table. Table travel on these machines resembles that of the ordinary planer. Designed for a wide variety of milling jobs, milling heads may be mounted on either of the two side columns or on the horizontal cross-rail with common or individual drives. Those for gang milling usually employ a single horizontal spindle, *Fig.* 2.

*Rotary Millers:* Usually of the vertical-spindle type, rotary millers, *Fig.* 13, are employed for contour and slab milling operations, channeling, milling tongues and jaws, trepanning, end milling, etc. These machines, however,

TABLE I

**Feeds per Tooth and Surface Speeds for Milling**

| Material Milled | Feed per Tooth | Peripheral Cutter Speed (sfpm) High-Speed Steel | Carbides |
|---|---|---|---|
| Carbon steels | 0.003-0.015 | 100 to 200 | 400 to 1,700 |
| Alloy steels | 0.002-0.012 | 50 100 | 400 1,150 |
| Armor plate | 0.006-0.030 | 30 50 | 400 800 |
| Cast & wrought irons | 0.005-0.030 | 50 200 | 400 1,200 |
| Stainless steels and monel | 0.002-0.030 | 60 150 | 500 1,200 |
| Copper & copper alloys | 0.005-0.030 | 70 400 | 550 10,000 |
| Beryllium copper | 0.006-0.009 | 30 50 | 150 5,000 |
| Zinc die-casting alloys | 0.006-0.015 | 300 1,000 | 600 2,000 |
| Aluminum alloys | 0.003-0.030 | 200 2,800 | 3,000 30,000 |
| Magnesium alloys | 0.003-0.030 | 375 2,800 | 3,000 30,000 |
| Glass-reinforced plastics | 0.005-0.015 | 30 50 | 400 800 |
| Fiber board | 0.012-0.015 | 300 800 | 600 1,500 |
| Plastics | 0.002-0.025 | 200 2,800 | 1,800 30,000 |
| Kinite | 0.010-0.015 | ... .... | 200 300 |

NOTE: Feed per tooth figures represent the wide range in general use today. High feeds per tooth are usually beneficial. Feeds per tooth for the harder and heat-treated materials fall to the lower side of the range and feeds for the normal, as-rolled or cast materials, to the high. Face mills, slab mills and fly cutters take the heaviest feed, with side or straddle, slotting, form, and end mills taking respectively lesser feeds with the saw at the very minimum. Cutters with few teeth produce better work with less chatter and generally the number of teeth should never exceed the number of inches of cutter diameter except to provide optimum feed per tooth for maximum efficiency of metal removal.

Peripheral surface speeds are only indicative of present-day range of values. Actually, no upper limit to peripheral cutter tip speeds has yet been found for many materials. Only the newer, high-powered and massive millers are capable of the high volume of metal removal per horsepower (over 3 cu in. per hp per min running to perhaps 10 cu in. per hp per min) afforded at the high side of the ranges.

are suited primarily to the production of large, heavy components in small or medium quantities. Where mass production is contemplated on parts with surfaces which can be face milled in a single pass a single-purpose type of rotary miller is employed. Jigs or fixtures mounted on the table provide for virtually continuous cutting, parts being loaded, passed first beneath the roughing and then the finishing spindle and automatically released for replacement with a rough part, *Fig.* 14.

An unusual departure from conventional rotary machines is the rotary head machine illustrated in *Fig.* 9. Suited primarily for tool, die and small quantity production, this miller adds a bit to the versatility of the rotary-table machine but is designed for much smaller size parts. Intricate radial cam work can be produced readily from drawings without the use of templates or patterns.

Another rotary, the drum type machine, having as many as five horizontal spindles is designed for mass production of large parts such as motor blocks, gear cases, clutch housings, etc. On these machines, parts are carried in fixtures mounted on a drum which rotates continuously, carrying the parts between face mills which can be adjusted to suit, *Fig.* 15.

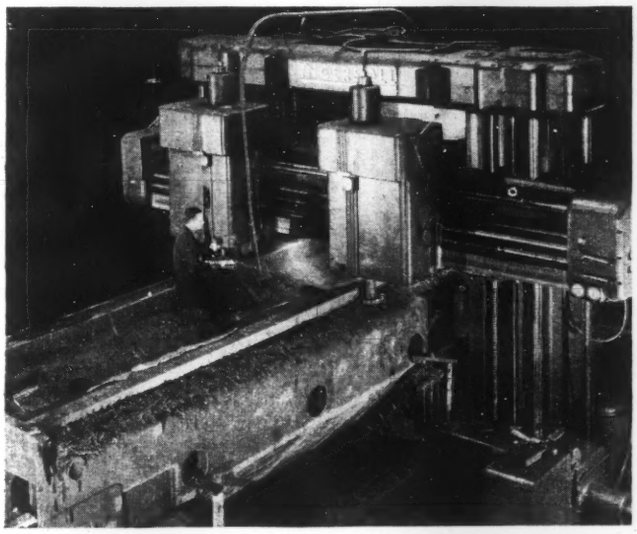
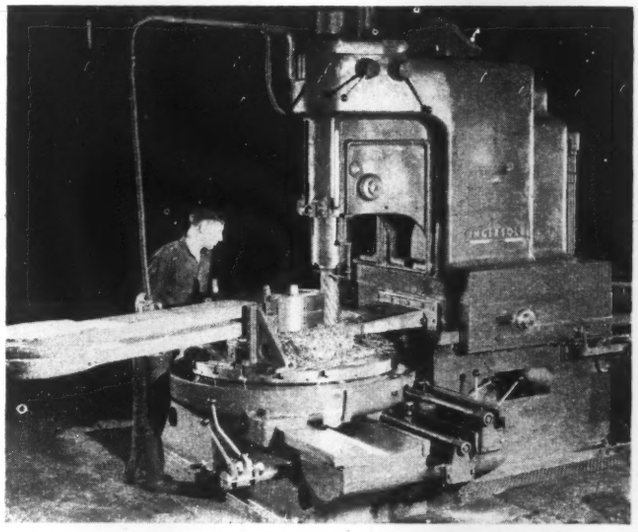


*Fig. 12—Above—Automatically controlled, this adjustable-rail machine can handle work 8 (high) by 9 by 34 feet*

*Fig. 13—Below—Rotary milling machine for special contours has a 54-inch diameter table and separately controlled table and spindle-housing adjustments*



What might be termed another type of rotary machine is the offset miller, which also uses a rotating table with fixtures. Cutters are carried on a short vertical spindle which rotates on an axis eccentric to the table axis. Suited primarily to production of small machine parts, the offset miller can perform facing, slotting, sawing, straddle milling and some simple form milling.

*Thread Millers:* Employing eccentric drums carrying the milling spindle, planetary milling machines derive their name from the automatic planetary action obtained. Adapted mainly to internal or external form milling as well as internal or external thread milling where high production is contemplated, the planetary machine simplifies the manufacture of parts which are difficult to hold or move. Both cutter rotation and feed are provided by the eccentric drums, the part milled being held stationary during the processing. For thread milling with multiple mills, the drums are provided with a lead screw feed and finish an entire thread in one revolution. Range of work

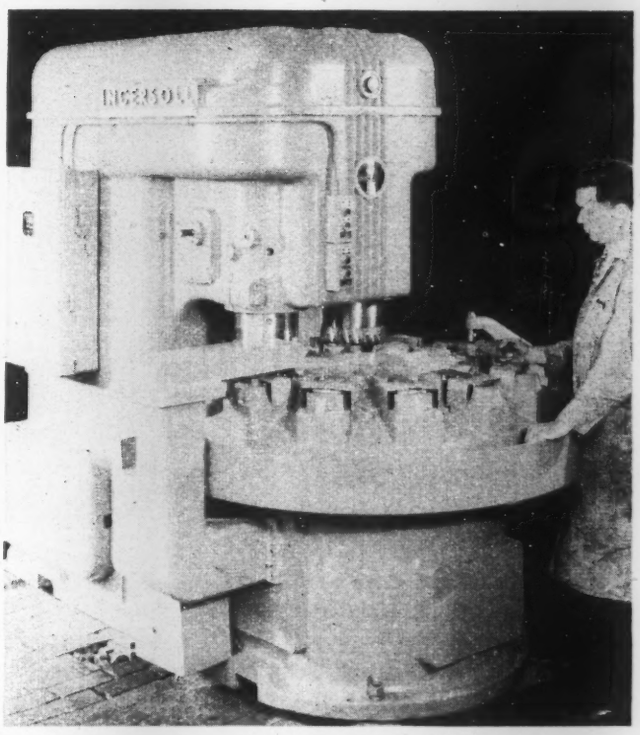
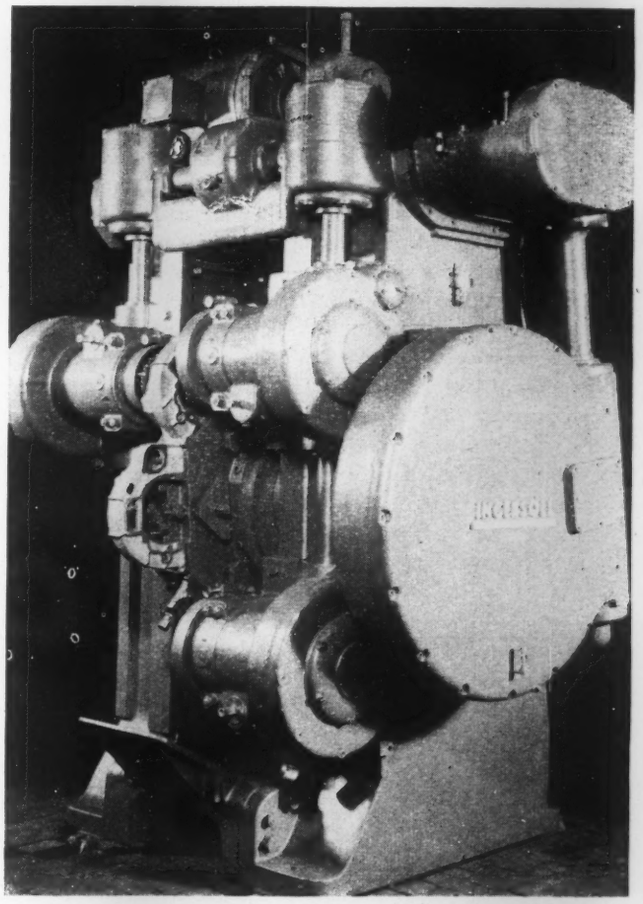


*Fig. 14—Above—Two-spindle rotary miller provides continuous semiautomatic production. The oil pump casings shown are finished at a rate of 190 per hour*

*Fig. 15—Below—Three-spindle drum miller for rough and finish carbide milling cylinder-block end of a clutch housing and milling one cut on transmission end. Operation is continuous, 91 housings being finished per hour*



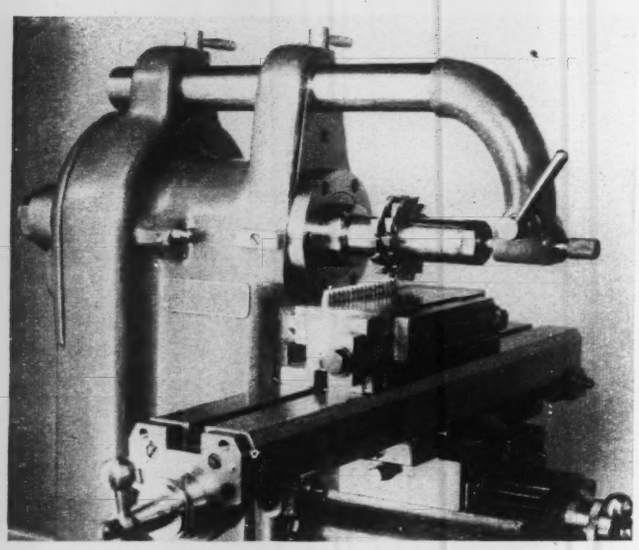
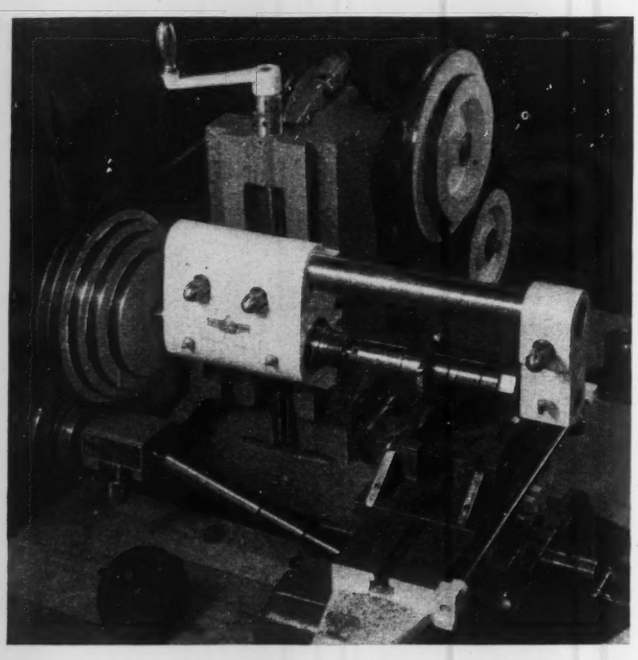


*Fig. 10—Above—Standard bench type universal, equipped with a special fixture for milling gun barrel rifling cutters*

*Fig. 11—Below—Automatic power feed bench millers provide a highly flexible production machine*



umn and knee type with one or two spindles. The dual-spindle machine can have the spindle spacing adjusted to suit, *Fig.* 1. Table movements are hand controlled, providing high sensitivity which makes them ideal for delicate operations on small parts. Use is confined principally to the manufacture of small quantities of light work.

*Fixed-Bed or Manufacturing Millers:* Manufacturing type machines, *Fig.* 9, as can be surmised, are designed primarily with an eye toward efficient production operations rather than overall general utility. They provide an extremely rigid construction and simple automatic operational characteristics for maximum economy in the mass production of small and medium-size parts. Available in either simplex or duplex models, the simplex miller has but one column on which the vertically adjustable spindle housing is mounted while the duplex has two opposed columns with vertically adjustable spindles. As indicated, fixed beds provide controlled longitudinal travel only.

*Planer Type Millers:* The common makes of planer type millers are primarily intended for producing one or more long straight surfaces on large, heavy machine parts, *Fig.* 12, or on a group of parts arranged in a series of fixtures on the table. Table travel on these machines resembles that of the ordinary planer. Designed for a wide variety of milling jobs, milling heads may be mounted on either of the two side columns or on the horizontal cross-rail with common or individual drives. Those for gang milling usually employ a single horizontal spindle, *Fig.* 2.

*Rotary Millers:* Usually of the vertical-spindle type, rotary millers, *Fig.* 13, are employed for contour and slab milling operations, channeling, milling tongues and jaws, trepanning, end milling, etc. These machines, however,

TABLE I

**Feeds per Tooth and Surface Speeds for Milling**

| Material Milled | Feed per Tooth | Peripheral Cutter Speed (sfpm) High-Speed Steel | | Carbides | |
|---|---|---|---|---|---|
| Carbon steels | 0.003-0.015 | 100 to | 200 | 400 to | 1,700 |
| Alloy steels | 0.002-0.012 | 50 | 100 | 400 | 1,150 |
| Armor plate | 0.006-0.030 | 30 | 50 | 400 | 800 |
| Cast & wrought irons | 0.005-0.030 | 50 | 200 | 400 | 1,200 |
| Stainless steels and monel | 0.002-0.030 | 60 | 150 | 500 | 1,200 |
| Copper & copper alloys | 0.005-0.030 | 70 | 400 | 550 | 10,000 |
| Beryllium copper | 0.006-0.009 | 30 | 50 | 150 | 5,000 |
| Zinc die-casting alloys | 0.006-0.015 | 300 | 1,000 | 600 | 2,000 |
| Aluminum alloys | 0.003-0.030 | 200 | 2,800 | 3,000 | 30,000 |
| Magnesium alloys | 0.003-0.030 | 375 | 2,800 | 3,000 | 30,000 |
| Glass-reinforced plastics | 0.005-0.015 | 30 | 50 | 400 | 800 |
| Fiber board | 0.012-0.015 | 300 | 800 | 600 | 1,500 |
| Plastics | 0.002-0.025 | 200 | 2,800 | 1,800 | 30,000 |
| Kinite | 0.010-0.015 | ... | .... | 200 | 300 |

NOTE: Feed per tooth figures represent the wide range in general use today. High feeds per tooth are usually beneficial. Feeds per tooth for the harder and heat-treated materials fall to the lower side of the range and feeds for the normal, as-rolled or cast materials, to the high. Face mills, slab mills and fly cutters take the heaviest feed, with side or straddle, slotting, form, and end mills taking respectively lesser feeds with the saw at the very minimum. Cutters with few teeth produce better work with less chatter and generally the number of teeth should never exceed the number of inches of cutter diameter except to provide optimum feed per tooth for maximum efficiency of metal removal.

Peripheral surface speeds are only indicative of present-day range of values. Actually, no upper limit to peripheral cutter tip speeds has yet been found for many materials. Only the newer, high-powered and massive millers are capable of the high volume of metal removal per horsepower (over 3 cu in. per hp per min running to perhaps 10 cu in. per hp per min) afforded at the high side of the ranges.

are suited primarily to the production of large, heavy components in small or medium quantities. Where mass production is contemplated on parts with surfaces which can be face milled in a single pass a single-purpose type of rotary miller is employed. Jigs or fixtures mounted on the table provide for virtually continuous cutting, parts being loaded, passed first beneath the roughing and then the finishing spindle and automatically released for replacement with a rough part, *Fig.* 14.

An unusual departure from conventional rotary machines is the rotary head machine illustrated in *Fig.* 9. Suited primarily for tool, die and small quantity production, this miller adds a bit to the versatility of the rotary-table machine but is designed for much smaller size parts. Intricate radial cam work can be produced readily from drawings without the use of templates or patterns.

Another rotary, the drum type machine, having as many as five horizontal spindles is designed for mass production of large parts such as motor blocks, gear cases, clutch housings, etc. On these machines, parts are carried in fixtures mounted on a drum which rotates continuously, carrying the parts between face mills which can be adjusted to suit, *Fig.* 15.

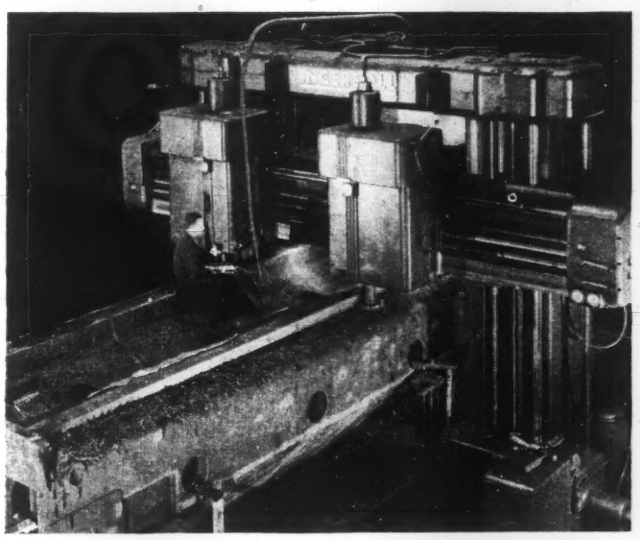
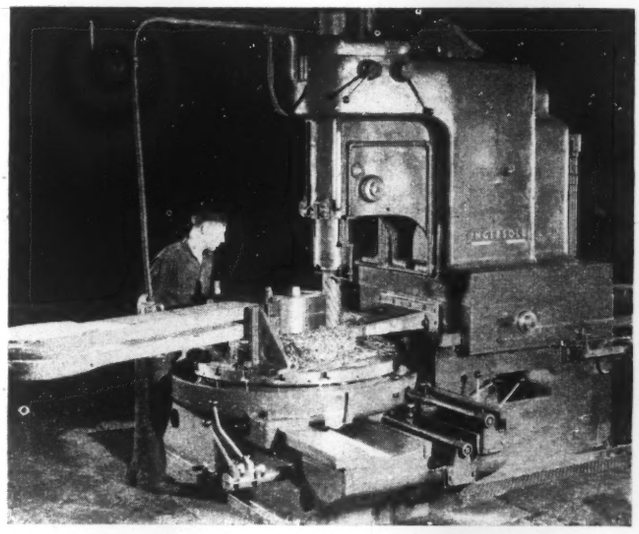


*Fig. 12—Above—Automatically controlled, this adjustable-rail machine can handle work 8 (high) by 9 by 34 feet*

*Fig. 13—Below—Rotary milling machine for special contours has a 54-inch diameter table and separately controlled table and spindle-housing adjustments*



What might be termed another type of rotary machine is the offset miller, which also uses a rotating table with fixtures. Cutters are carried on a short vertical spindle which rotates on an axis eccentric to the table axis. Suited primarily to production of small machine parts, the offset miller can perform facing, slotting, sawing, straddle milling and some simple form milling.

*Thread Millers:* Employing eccentric drums carrying the milling spindle, planetary milling machines derive their name from the automatic planetary action obtained. Adapted mainly to internal or external form milling as well as internal or external thread milling where high production is contemplated, the planetary machine simplifies the manufacture of parts which are difficult to hold or move. Both cutter rotation and feed are provided by the eccentric drums, the part milled being held stationary during the processing. For thread milling with multiple mills, the drums are provided with a lead screw feed and finish an entire thread in one revolution. Range of work

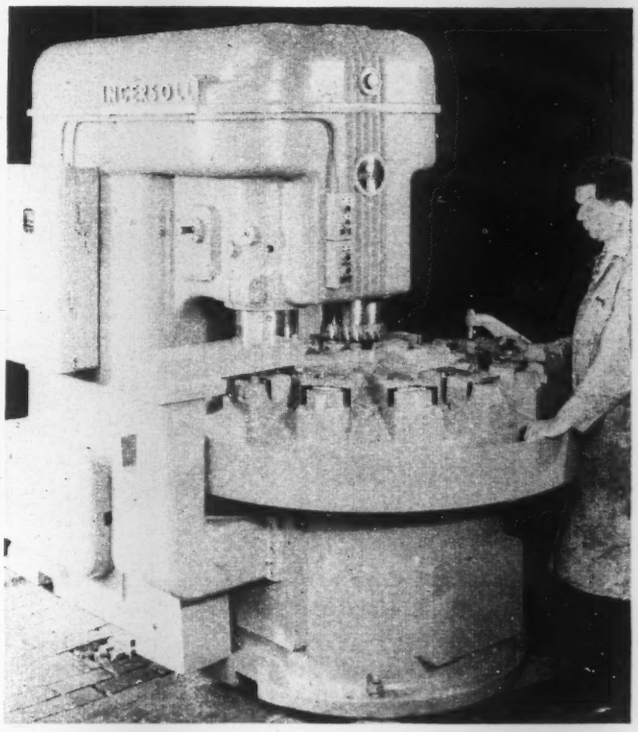
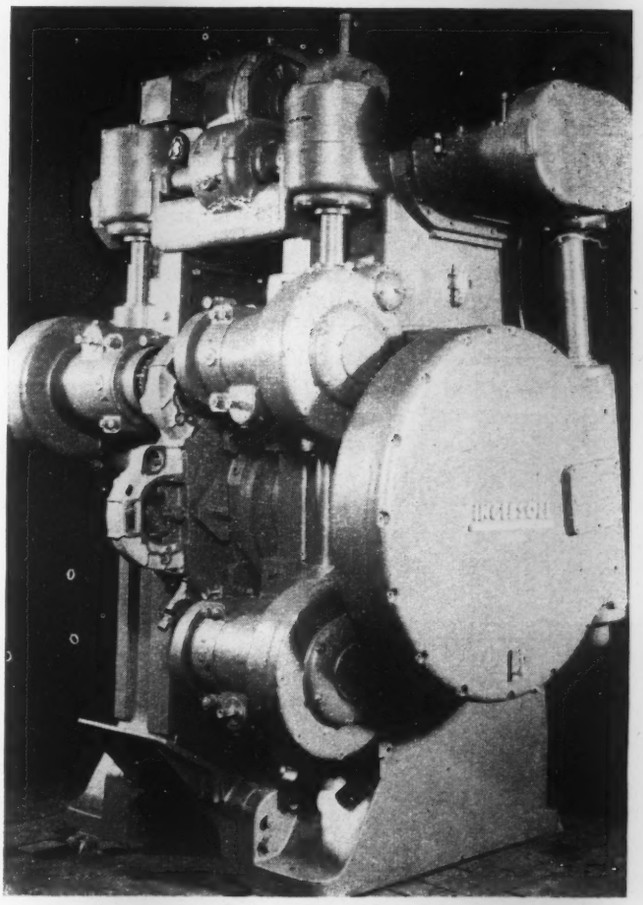


*Fig. 14—Above—Two-spindle rotary miller provides continuous semiautomatic production. The oil pump casings shown are finished at a rate of 190 per hour*

*Fig. 15—Below—Three-spindle drum miller for rough and finish carbide milling cylinder-block end of a clutch housing and milling one cut on transmission end. Operation is continuous, 91 housings being finished per hour*



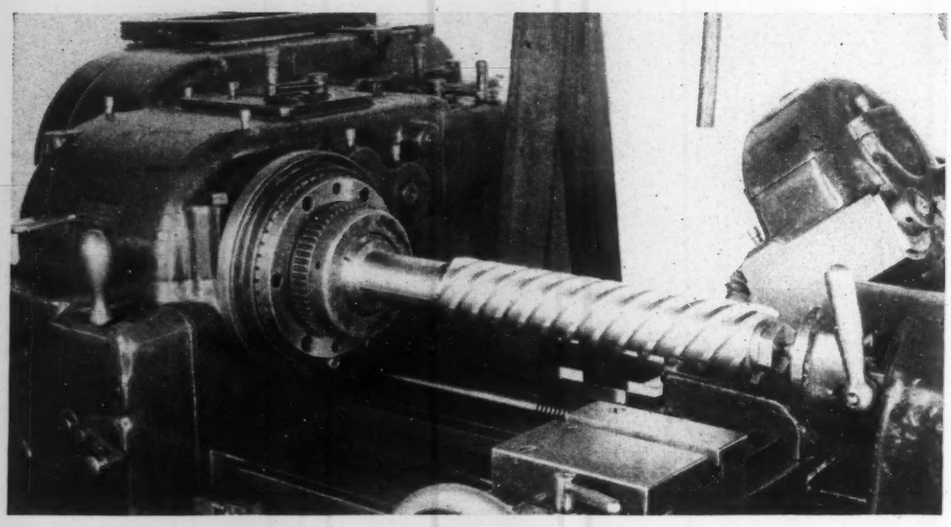
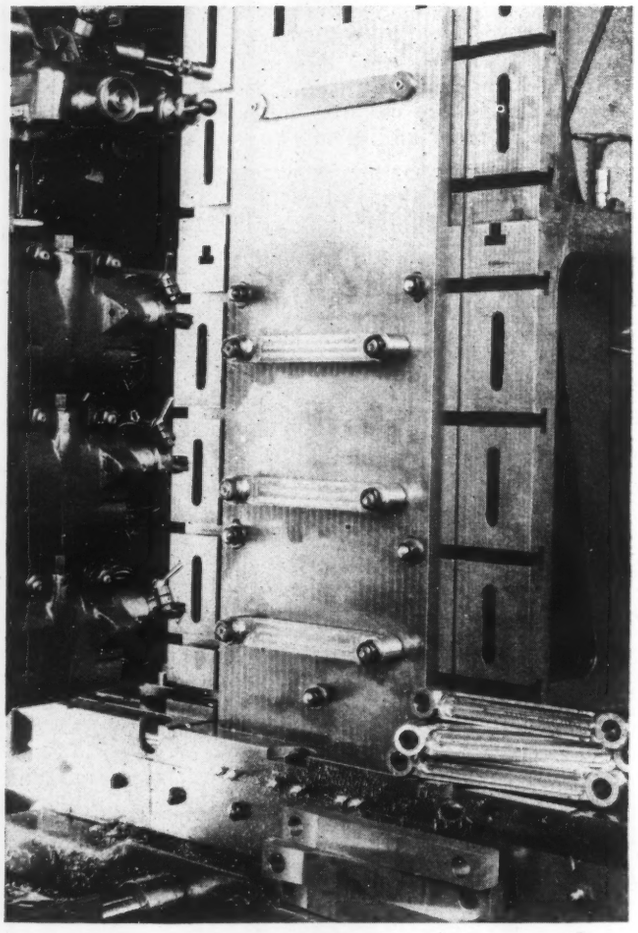


*Fig. 16 — Left — Steep lead, multiple start screws being produced on an automatic thread miller*

*Fig. 17—Below—External profiles of master and articulated aircraft connecting rods as well as channels and pockets are milled out automatically in multiples on this automatic tracer miller*



possible runs from about 0.312-inch to 20-inch external diameters and from about 0.625-inch to 20-inch internal diameters with thread leads up to 1.125-inches. For special operations many single-purpose variations of the planetary principle, both horizontal and vertical, are employed.

Less critical in their requirements and limitations regarding cutter design are the more common automatic offset thread millers, *Fig.* 16. These machines handle a wide range of internal and external threads, utilize standard or special single or multiple thread mills, and are available with either hand or power collet chucking, air chucking, or with hollow spindles having chucks or fixtures. Parts which can be handled range from precision threads on small shafts to cannon breech-lock threads.

*Automatic Tracer Millers:* Whereas the rotary-head machine discussed under rotary millers eliminates the need for templates or patterns in the production of small quantities of complicated forms, cams, etc., when mass production is required an automatic tracer miller is indicated, *Fig.* 17. A variety of vertical and horizontal tracers are available and represent the ideal machine for the production milling of odd shape parts such as connecting rods, complicated gear housings, extremely large or small cam tracks of intricate shape, etc. Intricate machine parts can be profiled in stacks or groups where high accuracy for interchangeability is necessary but quantity does not warrant expensive tooling.

*Special-Purpose Millers:* The number and design of special-purpose millers is probably as unlimited as the design of machine parts themselves. However, with the exception of a few machines, special-purpose millers are designed to perform a solitary job made necessary by a particular machine part design or by failure to recognize the limitations of readily available standard millers. Where quantity is sufficiently large a special machine can, in many cases, offset its cost by virtue of increased output and automaticity. It is a fact, though, that many, many cases continue to recur which point up the value in considering machine capabilities during early design stages.

Special-purpose millers designed specifically for the mass production of aircraft wing spars, *Fig.* 18, undoubtedly are outstanding machines for reasons of design achievement if not alone for the contribution to the advancement of the art of metal cutting. These machines were developed from early tests of aluminum milling with common woodworking machines. Starting with cutter speeds of about 7500 sfpm, they have been developed continuously until today speeds as high as 30,000 sfpm can be used at metal removal rates of 2 cubic inches per horsepower per minute and on up. Typical cutters used are two-lipped, with heavy Meehanite or boiler-plate bodies, are carbide tipped and symmetrical.

To obviate the cost limitations of special-purpose spar millers, a universal mill was designed to incorporate as many as possible of the previously developed motions—twist, vertical and horizontal. Shown in *Fig.* 18, this ma-

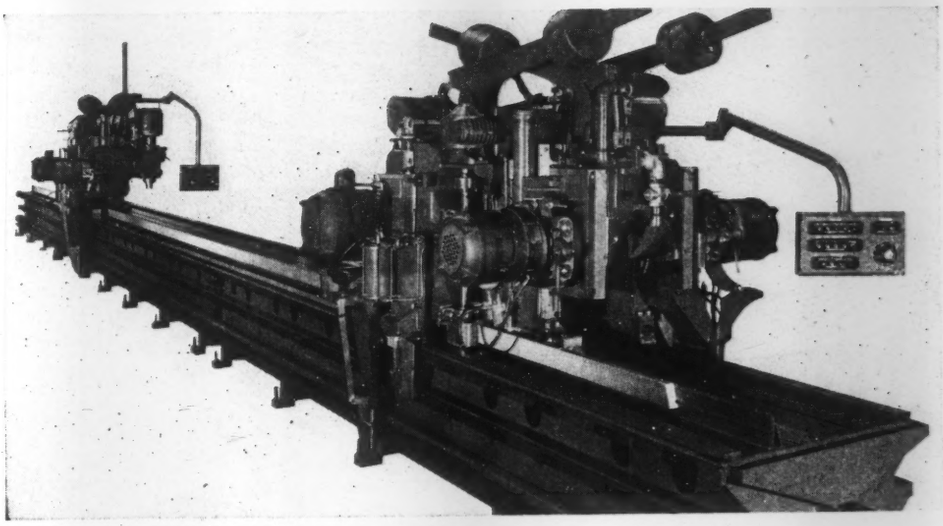


*Fig. 18—Right—Universal miller for aluminum aircraft wing spars designed to accommodate widely varying or changing designs*

chine will accommodate spars up to 51 feet long and can be separated to form two single-head units. Thus one highly flexible miller makes possible continual improvement in the design of spars with only minor changes in cam tracks, cutters and fixtures.

In addition to these machines, which are primarily intended for highly efficient milling of aluminum alloys, another group of special machines now in use also operates in the high-speed milling range. These, the high-cycle millers, utilize high-cycle motors directly as the milling spindle and turn at speeds ranging from around 3000 rpm to 15,000 rpm. Both ferrous as well as nonferrous materials are milled with these machines at table feeds ranging up to 300 inches per minute, production in some cases being as much as 1500 per cent greater than that possible with ordinary methods.

The counterpart of the automatic screw machine—the bar stock automatic miller—for mass production of surfaces, forms, shapes, etc., adapted primarily to milling, utilizes bar stock of almost any cross section desired, mills it to a specified shape or shapes, and cuts it off. The part at this point is either completely finished or ready for final finishing.

Shown in *Fig.* 19, this automatic miller has a three-spindle head hydraulically actuated in a vertical direction. The cycle is continuous, including rapid advance down, feed forming cutters, jump, feed cutoff saw, reverse, and rapid return up. One lower spindle is adjustable. Rollers powered by a torque motor feed the bar stock against a stop, and hydraulically actuated clamps hold the stock during milling. The entire sequence of producing one piece actually consumes but a small fraction of a second. A wide variety of parts, such as turbine buckets, latch dogs, refrigerator hinges, door latches, limit switch parts, etc., where surface and shapes to be generated are in parallel relation as in broaching, can be produced readily with economy matching that of the automatic screw machine.

The concluding portion of this article, Part XXII—Production Milling—Design Factors, will deal with design for milling, characteristics and suitability of materials, and tolerances maintained in the production of machine parts with the various methods of milling.

Collaboration of the following companies in the preparation of this article as well as the assistance lent by Dr. H. A. Frommelt, consulting engineer on carbide milling, Milwaukee, is acknowledged with much appreciation:

Aircraft Machinery Corp. (*Fig.* 11) ..... San Francisco
Brown & Sharpe Co. ..... Providence, R. I.
Carboloy Co. Inc. ..... Detroit
Cincinnati Milling Machine Co. (*Fig.* 4) ..... Cincinnati
Farnham Mfg. Co. (*Figs.* 8 and 18) ..... Buffalo
Illinois Tool Works (*Fig.* 3) ..... Chicago
Ingersoll Milling Machine Co.
(*Figs.* 2, 12, 13, 14, 15). ..... Rockford, Ill.
Kearney & Trecker Corp. (*Fig.* 9) ..... Milwaukee
Kennametal, Inc. (*Figs.* 5, 7) ..... Latrobe, Pa.
Kent-Owens Machine Co. (*Fig.* 19) ..... Toledo, Ohio
Machinery Mfg. Co. ..... Los Angeles
Motor Tool Mfg. Co. ..... Detroit
National Twist Drill & Tool Co. (*Fig.* 3.) Rochester, Mich.
W. H. Nichols & Sons (*Fig.* 1) ..... Waltham, Mass.
Plan-O-Mill Corp. ..... Hazel Park, Mich.
Pratt & Whitney (*Figs.* 10, 16 and 17) West Hartford, Conn.

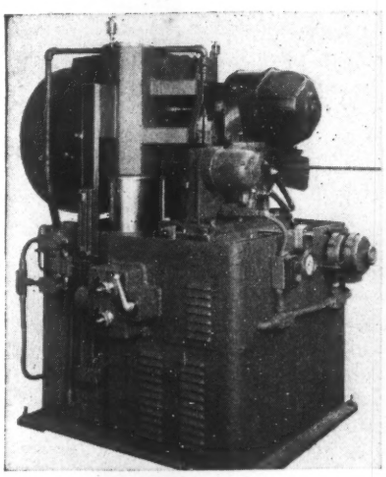
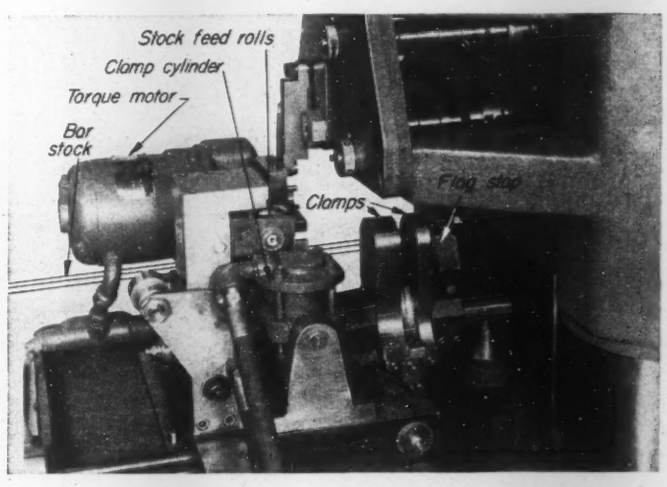


*Fig. 19—Automatic bar stock milling machine, left, mass produces milled parts from bar stock, right, in a manner not unlike that of the well-known automatic screw machine*



## *Stress calculations and analysis for disk profiles with external loading*

By A. H. Ehlinger

*Blower and Compressor Dept.*
*Allis-Chalmers Mfg. Co.*
*Milwaukee, Wis.*

ENGINEERS have been dealing with the theory of rotating disks for at least fifty years. As a result, suitable equations have been developed to handle disks of several types and, in addition, the well known sum and difference graphical method is available for solution of the many disks which are too difficult to handle analytically. Too often however, the use of these methods has reduced the rotating-disk problem to a process of substituting values in equations or going through the graphical solution in a sort of mechanical fashion.

The purpose of this article is to review the fundamental theory of rotating disks and to link this theory to some of the existing methods of handling disk problems. Stress equations will be developed for the thin ring and the constant-thickness disk. These equations will then be used as a basis for the sum and difference method and its application. Finally, there will be a brief discussion of equations for the profiles of solid disks with external loading.

Stresses in a rotating disk, such as illustrated in *Fig.* 1, are due to centrifugal force acting on the masses in the disk or attached to the disk. The principal stresses considered consist of radial stress acting in line with the radii of the disk, and tangential stresses acting normal to the direction of the radial stresses. The method of stress analysis employed is based upon the relationship of values of stress to values of strain. This system of analysis, commonly known as the theory of elasticity, is built up around the equation for unit elongation in the stressed member. For the rotating disk, unit elongations in the tangential and radial directions are expressed in terms of

NOMENCLATURE

| | |
|---|---|
| $A$ | = Area of half section of disk (sq in.) |
| $b$ | = Axial thickness of disk (in.) |
| $b_o$ | = Thickness of disk at outside diameter (in.) |
| $D$ | $= \sigma_t - \sigma_r$ |
| $E$ | = Young's modulus of elasticity |
| $e_r$ | = Unit elongation in radial direction (in./in.) |
| $e_t$ | = Unit elongation in tangential direction (in./in.) |
| $F$ | = Total external load on disk (lb) |
| $g$ | = Acceleration due to gravity (in./sec$^2$) = 386 |
| $I$ | = Moment of inertia of area of half section about axis of rotation (in.$^4$) |
| $m$ | = Total displacement in radial direction (in.) |
| $r$ | = Radius from axis of rotation (in.) |
| $r_i$ | = Radius of disk at inside diameter (in.) |
| $r_o$ | = Radius of disk at outside diameter( in.) |
| $S$ | $= \sigma_t + \sigma_r$ |
| $t$ | = Radial thickness of thin ring (in.) |
| $u$ | = $\omega r/12$ linear velocity of disk (ft/sec) |
| $Z$ | = Radial load on disk (lb/in. of periphery) |
| $\gamma$ | = Density of disk (lb/in.$^3$) |
| $\mu$ | = Poisson's ratio |
| $\rho$ | $= \gamma/g$ |
| $\sigma$ | = Tangential stress in thin ring (psi) |
| $\sigma_h$ | = Stress at center of solid disk (psi) |
| $\sigma_r$ | = Radial stress in disk (psi) |
| $\sigma_{ri}$ | = Radial stress at inside diam., internal loading (psi) |
| $\sigma_{ro}$ | = Radial stress at outside diam. external loading (psi) |
| $\sigma_t$ | = Tangential stress in disk (psi) |
| $\sigma_{tm}$ | = Average tangential stress in disk (psi) |
| $\omega$ | = Angular velocity of disk (radians/sec) |

*Fig. 1 — Design of forged wheel and shaft for mechanical drive impulse turbine involves application of rotating-disk analysis, with external loading due to blades*

the principal stresses at any point within the disk by the following equations (see Nomenclature):

$$e_t=\frac{1}{E}(\sigma_t-\mu\sigma_r) \quad \ldots\ldots (1)$$

$$e_r=\frac{1}{E}(\sigma_r-\mu\sigma_t) \quad \ldots\ldots (2)$$

This analysis will deal with a constant-thickness disk whose sides are normal to the axis of rotation. Before considering the disk itself, the stress in a thin ring of width $b$ and radial thickness $t$ as shown in *Fig.* 2 will first be analyzed. When this ring is rotating about its own axis at $\omega$ radians per second, centrifugal forces will act on the masses in the ring in a radial direction. If $r$ is the mean radius of the ring and $f$ equals the sum of the centrifugal forces acting on one inch of circumference of the ring, then

$$f=\rho bt\omega^2 r \quad \ldots\ldots (3)$$

The force acting on an element of the ring having a peripheral length $rd\theta$ will be $frd\theta$, which can be resolved into two components, namely, $fr\ cos\ \theta d\theta$ and $fr\ sin\ \theta d\theta$. If one half of the ring is considered as a free body, measuring angle $\theta$ in either direction from the midpoint of the half ring, it can be seen that each $fr\ sin\ \theta d\theta$ component in the upper quadrant will be balanced by an equal component in the lower quadrant. The horizontal components, however, will not cancel out but must be balanced by tangential force $P$ due to the tangential stress in the ring. The values of $P$ can be determined by summing up all of the increments as follows:

$$P=2\int_0^{\frac{\pi}{2}} fr\cos\theta d\theta=2fr$$

Substituting $\rho bt\omega^2 r$ for $f$,

$$P=2\rho bt\omega^2 r^2$$

Force $P$ produces a purely tangential stress in the ring which is referred to as the hoop stress in the ring and will be represented by the symbol $\sigma_h$. Assuming force $P$ is evenly distributed over the sectional area of the ring, then $\sigma_h$ may be expressed as follows:

$$\sigma_h=\frac{P}{2A}=\frac{2\rho bt\omega^2 r^2}{2bt}=\rho\omega^2 r^2=\frac{\gamma\omega r^2}{386} \quad \ldots\ldots (4)$$

In terms of peripheral velocity of the ring

$$\sigma_h=0.373\gamma u^2 \quad \ldots\ldots (4a)$$

Elongation of this ring due to hoop stress will equal $2\pi r\sigma_h/E$, resulting in an increase in radius of $r\sigma_h/E$.

Getting back to the constant-thickness disk and imagining it to be made up of a number of thin rings fitted closely over one another, each ring, upon rotation, would have a radial displacement of

$$m=\frac{r}{E}\sigma_h=\frac{\rho\omega^2 r^3}{E} \quad \ldots\ldots (5)$$

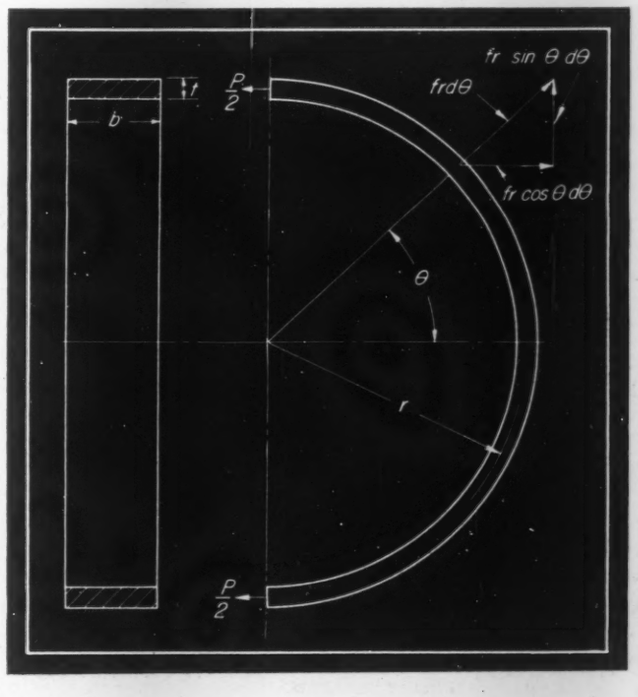
Considering the disk to be made up of elemental thin rings, it is evident that radial forces are exerted on these rings to hold them together. If one half of an elemental ring were taken as a free body as shown in *Fig.* 3, then, in addition to centrifugal forces on the mass of the ring, there would also be external forces on the ring due to radial stresses. Assuming these radial stresses to be in tension, the inward radial force per inch of periphery would be $b\sigma_r$ and the outward radial force per inch of periphery would be $b(\sigma_r+d\sigma_r)$. Summing up the horizontal components of all external radial forces,

$$P'=2b(rd\sigma_r+\sigma_r dr+d\sigma_r dr)$$

Where $P'$ is the tangential force on the half ring required to balance the external forces. Neglecting differentials of the second order, the actual stress in the elemental ring can be expressed as

$$\sigma_t=\sigma_h+\frac{P'}{2dA}=\sigma_h+r\frac{d\sigma_r}{ar}+\sigma_r$$

*Fig. 2—One half of a rotating thin ring considered as a free body*



Rearranging terms, the following equation is obtained,

$$\frac{d\sigma_r}{dr}+\frac{1}{r}(\sigma_h+\sigma_r-\sigma_t)=0 \quad \ldots\ldots (6)$$

To solve Equation 6 the values of stress must be expressed in terms of radial displacement of the disk. By definition

$$e_t=\frac{2\pi(r+m)-2\pi r}{2\pi r}=\frac{m}{r} \quad \ldots\ldots (7)$$

$$e_r=\frac{dm}{dr} \quad \ldots\ldots (8)$$

Substituting these values in Equations 1 and 2 and solving for $\sigma_t$ and $\sigma_r$,

$$\sigma_t=\frac{E}{1-\mu^2}\left(\frac{m}{r}+\mu\frac{dm}{dr}\right) \quad \ldots\ldots (9)$$

$$\sigma_r=\frac{E}{1-\mu^2}\left(\frac{\mu m}{r}+\frac{dm}{dr}\right) \quad \ldots\ldots (10)$$

$$\frac{d\sigma_r}{dr}=\frac{E}{1-\mu^2}\left(\mu r\frac{dm}{dr}-\mu m}{r^2}+\frac{d^2m}{dr^2}\right) \quad \ldots\ldots (11)$$

Substituting the foregoing values in Equation 6,

$$\frac{d^2m}{dr^2}+\frac{1}{r}\frac{dm}{dr}-\frac{m}{r^2}+\frac{1-\mu^2}{E}\frac{\sigma_h}{r}=0 \quad \ldots\ldots (12)$$

Substituting

$$\sigma_h=\rho\omega^2r^2 \quad \ldots\ldots (13)$$

in Equation 12, then

$$\frac{d^2m}{dr^2}+\frac{1}{r}\frac{dm}{dr}-\frac{m}{r^2}+\frac{1-\mu^2}{E}\rho\omega^2r=0 \quad \ldots\ldots (14)$$

It can be verified that the solution of Equation 14 is

$$m=C_1r+\frac{C_2}{r}-\frac{(1-\mu^2)\rho\omega^2r^3}{8E} \quad \ldots\ldots (15)$$

Therefore

$$\frac{m}{r}=C_1+\frac{C_2}{r^2}-\frac{(1-\mu^2)\rho\omega^2r^2}{8E} \quad \ldots\ldots (16)$$

and

$$\frac{dm}{dr}=C_1-\frac{C_2}{r^2}-\frac{3(1-\mu^2)\rho\omega^2r^2}{8E} \quad \ldots\ldots (17)$$

Also

$$\frac{d^2m}{dr^2}=2\frac{C_2}{r^3}-\frac{6(1-\mu^2)\rho\omega^2r}{8E} \quad \ldots\ldots (18)$$

Substituting the foregoing values in Equations 9 and 10 the following general equations for tangential stress, radial stress, and radial displacement in a constant thickness disk are obtained.

$$\sigma_t=\frac{E}{1-\mu}C_1+\frac{E}{1+\mu}\frac{C_2}{r^2}-\frac{1+3\mu}{8}\rho\omega^2r^2 \quad \ldots\ldots (19)$$

$$\sigma_r=\frac{E}{1-\mu}C_1-\frac{E}{1+\mu}\frac{C_2}{r^2}-\frac{3+\mu}{8}\rho\omega^2r^2 \quad \ldots\ldots (20)$$

$$m=C_1r+\frac{C_2}{r}-\frac{1-\mu^2}{8E}\rho\omega^2r^3 \quad \ldots\ldots (21)$$

Values of constants $C_1$ and $C_2$ will depend upon the boundary conditions of the disk. For a solid disk, that is, a disk without a central hole, the value of $m$ is zero at the center of the disk and Equation 21 becomes

$$m=C_1r+\frac{C_2}{r}-\frac{1-\mu^2}{8E}\rho\omega^2r^3=0$$

Multiplying through by $r$ gives

$$C_1r^2+C_2-\frac{1-\mu^2}{8E}\rho\omega^2r^4=0$$

Therefore, since $r$ is equal to zero for this case,

$$C_2=0$$

When there is no external load on the disk $\sigma_r$ is equal to zero when $r$ is equal to $r_o$ and Equation 20 becomes:

$$\sigma_r=\frac{E}{1-\mu}C_1-\frac{3+\mu}{8}\rho\omega^2r_0^2=0$$

Therefore

$$C_1=\frac{(3+\mu)(1-\mu)}{8E}\rho\omega^2r_0^2$$

Substituting for $C_1$ and $C_2$ in Equations 19 and 20 the following stress equations are obtained for a constant-thickness solid disk with no external loading

$$\sigma_t=\frac{\rho\omega^2}{8}\left[(3+\mu)r_0^2-(1+3\mu)r^2\right] \quad \ldots\ldots (22)$$

$$\sigma_r=\frac{3+\mu}{8}\rho\omega^2((r_0^2-r^2) \quad \ldots\ldots (23)$$

For a disk with a hole at its center having no external loading, radial stress is equal to zero at the outside diameter of the disk as well as at its bore. Therefore Equation 20 becomes,

$$\frac{E}{1-\mu}C_1-\frac{E}{1+\mu}\frac{C_2}{r_0^2}-\frac{3+\mu}{8}\rho\omega^2r_0^2=$$

$$\frac{E}{1-\mu}C_1-\frac{E}{1+\mu}\frac{C_2}{r_i^2}-\frac{3+\mu}{8}\rho\omega^2r_i^2$$

$$C_2=\frac{(3+\mu)(1+\mu)}{8E}\rho\omega^2r_0^2r_i^2$$

Using this expression for $C_2$ in Equation 20

$$\sigma_{ri}=\frac{E}{1-\mu}C_1-\frac{3+\mu}{8}\rho\omega^2r_0^2-\frac{3+\mu}{8}\rho\omega^2r_i^2=0$$

$$C_1=\frac{(3+\mu)(1-\mu)}{8E}\rho\omega^2(r_0^2+r_i^2)$$

Substituting these values for $C_1$ and $C_2$ in Equations

19 and 20, the following stress equations for a constant thickness disk with a central hole and no external loading are obtained:

$$\sigma_t=\frac{\rho\omega^2}{8}\left[(3+\mu)\left(r_0^2+r_i^2+\frac{r_0^2r_i^2}{r^2}\right)-(1+3\mu)r^2\right] \quad \ldots\ldots(24)$$

$$\sigma_r=\frac{3+\mu}{8}\rho\omega^2\left(r_0^2+r_i^2-\frac{r_0^2r_i^2}{r^2}-r^2\right) \quad \ldots\ldots(25)$$

For disks with external loading at their extreme diameters, the radial stresses at maximum and minimum diameters can be calculated readily and constants $C_1$ and $C_2$ then become functions of $r_o$, $r_i$, $\sigma_{ro}$ and $\sigma_{ri}$. When external loading is expressed as Z pounds per inch of periphery, the radial stress due to the external load is equal to $Z/b$, where $b$ is equal to the thickness of the disk.

### The Sum and Difference Method

The sum and difference method, developed by M. Donath, is a system for solving constant-thickness disks graphically. It can be used readily for disks carrying external loading and is especially useful because it can be adapted to the analysis of a disk of nonuniform thickness. In the latter case the nonuniform disk is divided into a series of constant-thickness disks joined at their extreme diameters to form an equivalent disk, as shown in *Fig.* 5.

Adding Equations 19 and 20

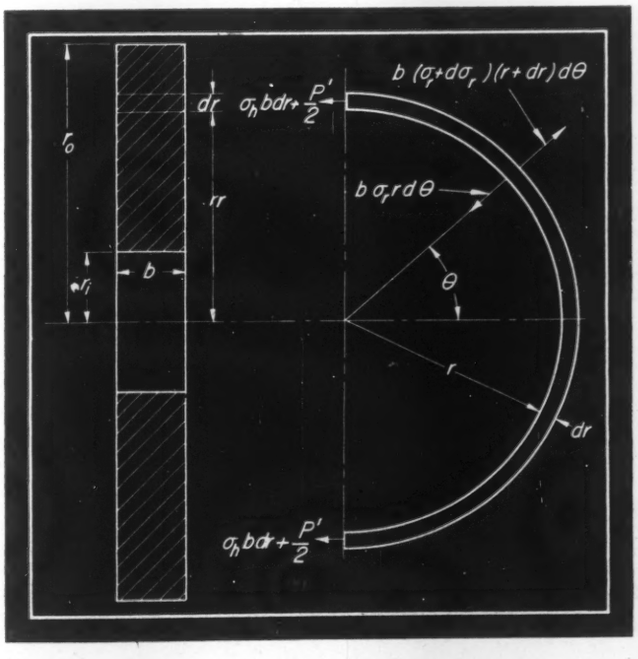
$$S=\sigma_t+\sigma_r=\frac{2E}{1-\mu}C_1-\frac{1+\mu}{2}\rho\omega^2r^2$$

$$=\frac{2E}{1-\mu}C_1-\frac{72}{386}(1+\mu)\gamma u^2 \quad \ldots\ldots(26)$$

Subtracting Equation 20 from 19

$$D=\sigma_t-\sigma_r=\frac{2E}{1+\mu}\frac{C_2}{r^2}+\frac{1-\mu}{4}\rho\omega^2r^2$$

***Fig. 3—Section through constant-thickness disk and end view of half ring considered as an element of the disk***




$$=\frac{E}{1+\mu}\frac{\omega^2C_2}{72u^2}+\frac{36}{386}(1-\mu)\gamma u^2 \quad \ldots\ldots(27)$$

For a given disk rotating at constant speed, values of $E$, $\mu$, $\gamma$, $\omega$, $C_1$ and $C_2$ remain constant. Therefore, when values of $S$ and $D$ are plotted against values of $u$ there will be one $S$ curve and one $D$ curve for any given disk. The $S$ and $D$ chart used for graphical solution consists of a large number of $S$ and $D$ curves all plotted against values of $u$. One of these charts is shown in *Fig.* 4. The method of solving a disk consists of finding the set of $S$ and $D$ curves which satisfy the disk.

As a basis for selecting the $S$ curve and the $D$ curve for a given disk, $\sigma_t$ and $\sigma_r$ are expressed in terms of $S$ and $D$. From Equations 26 and 27,

$$\sigma_t=\frac{S+D}{2} \quad \ldots\ldots(28)$$

$$\sigma_r=\frac{S-D}{2} \quad \ldots\ldots(29)$$

To solve a disk with a central hole, procedure is as follows:

1. Find the values of $u$ corresponding to the extreme diameters of the disk
2. Determine the external load on the disk and calculate $\sigma_r$ for the extreme diameters (when there is no external load, $\sigma_r$ is equal to zero)
3. Substitute the values for $\sigma_r$ at the extreme diameters in Equation 29 and find the set of $S$ and $D$ curves on the chart which satisfy these values
4. Using the $S$ and $D$ curves selected in step 3, the values of $\sigma_t$ and $\sigma_r$ can be calculated for any radius

In solving a solid disk $\sigma_t$ is equal to $\sigma_r$ at the center of the disk. This makes $D$ equal zero when $u$ is equal to zero. Therefore, the $D$ curve passing through zero will satisfy all solid disks. Follow this $D$ curve to the value of $u$ corresponding to the outside diameter of the disk. Now calculate $\sigma_r$ from the external load on the disk and select the $S$ curve which satisfies Equation 29. The correct $S$ and $D$ curves will seldom be found on the chart, but when a sheet of tracing paper is laid over the chart the exact curves can readily be sketched on the tracing.

To solve a disk of nonuniform thickness with external loading, it is necessary to divide the disk into a series of constant thickness disks, which, for convenience, will be called sections. There will now be a set of $S$ and $D$ curves for each section. Solution of the disk is obtained by successive trials to find the correct combination of $S$ and $D$ curves.

Having a trial set of $S$ and $D$ curves for one section, it is possible to calculate $\Delta S$ and $\Delta D$ to obtain new values for $S$ and $D$ for the adjacent section. Formulas for $\Delta S$ and $\Delta D$ are derived as follows:

Letting the prime sign designate values for the adjacent section, and referring to sections 2 and 3 in *Fig.* 5, radial displacement at radius $r$ can be expressed as follows:

$$m=\frac{r}{E}(\sigma_t-\mu\sigma_r)=\frac{r}{E}(\sigma_t'-\mu\sigma_r')+re(\Delta t)$$

where $e$ = thermal expansion per unit length per degree of temperature difference. $\Delta t = t' - t$ = change in temperature between the adjacent sections. It is assumed that the temperature remains constant throughout any

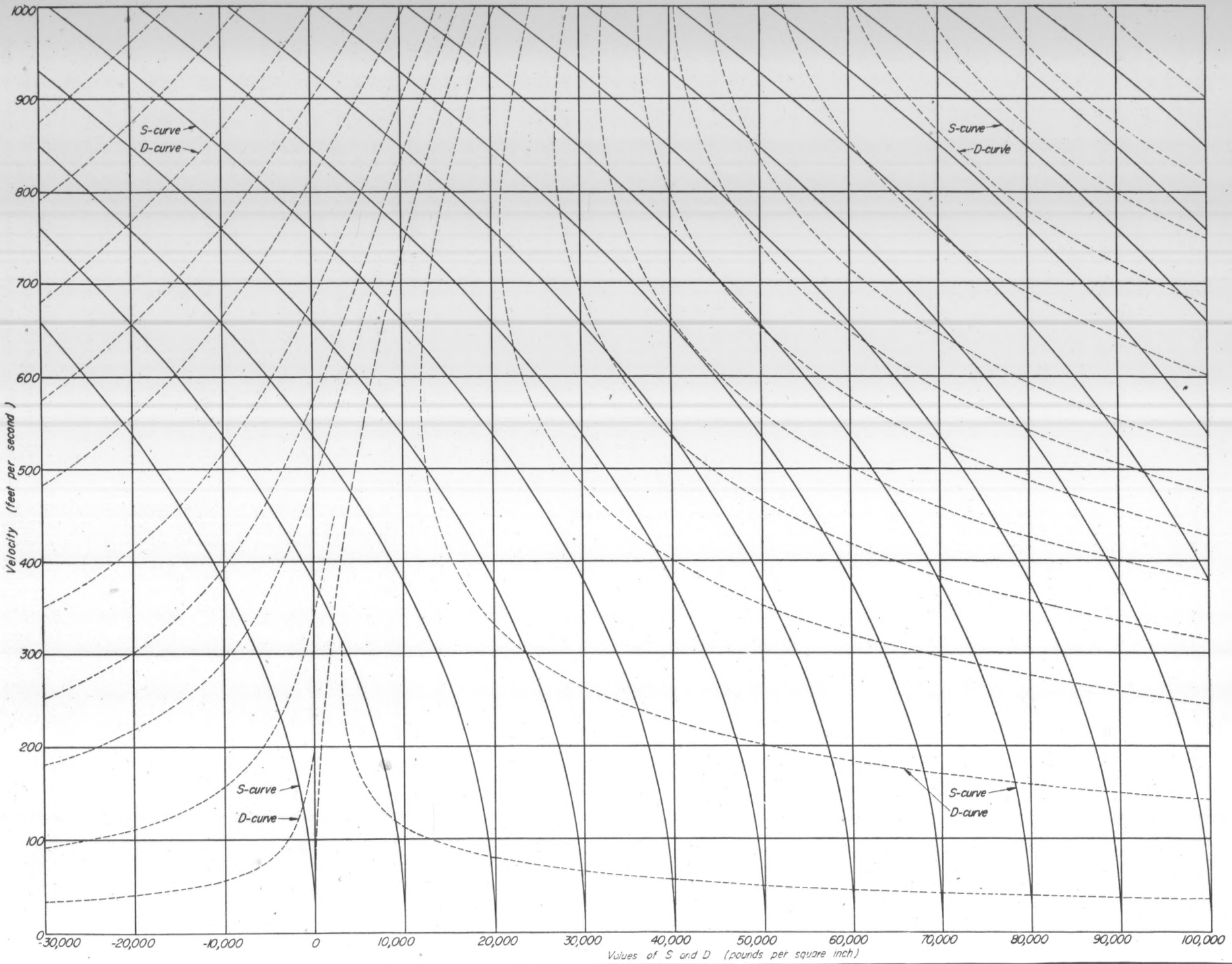

Velocity (feet per second)
1000
900
800
700
600
500
400
300
200
100
0
S-curve
D-curve
S-curve
D-curve
S-curve
D-curve
S-curve
D-curve
-30,000
-20,000
-10,000
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
90,000
100,000
Values of S and D (pounds per square inch)

*Fig. 4—Left—Chart for determining stresses in a rotating disk. Curves marked S and D represent, respectively, the sum and differences of the tangential and radial stresses (A 26 by 34-inch chart containing intermediate S and D-curves will gladly be sent to readers upon request—ED.)*

given section, thus giving the thermal expansion $re(\Delta t)$. The temperature of the section may be considered equal to the actual temperature at the mean radius of the section.

If the temperature differentials between adjacent sections are not unduly large, the value of $E$ may be considered the same for each section. Multiplying through the foregoing equation by $E/r$,

$$\sigma_t - \mu\sigma_r = \sigma_t' - \mu\sigma_r' + Ee(\Delta t)$$

$$\sigma_t' - \sigma_t = u(\sigma_r' - \sigma_r) - Ee(\Delta t)$$

or

$$\Delta\sigma_t = \mu(\Delta\sigma_r) - Ee(\Delta t) \quad \ldots\ldots (30)$$

Also

$$S' = \sigma_t' + \sigma_r' \; ; \; S = \sigma_t + \sigma_r$$

$$\Delta S = S' - S = \Delta\sigma_t + \Delta\sigma_r \quad \ldots\ldots (31)$$

Likewise

$$\Delta D = D' - D = \Delta\sigma_t' - \Delta\sigma_r \quad \ldots\ldots (32)$$

Now assuming that the external load attached to section 3 is carried by section 2 and is expressed as $Z$ pounds per inch of periphery at radius $r$, then

$$\sigma_t b = \sigma_r' b' + Z'$$

$$\sigma_r' = \frac{b}{b'}\sigma_r - \frac{Z'}{b'}$$

$$\sigma_r - \sigma_r' = \frac{b}{b'}\sigma_t - \sigma_t - \frac{Z'}{b'}$$

or

$$\Delta\sigma_r = \left(\frac{b}{b'} - 1\right)\sigma_t - \frac{Z'}{b'} \quad \ldots\ldots (33)$$

From Equation 30

$$\Delta\sigma_t = \mu\left[\left(\frac{b}{b'} - 1\right)\sigma_r - \frac{Z'}{b'}\right] - Ee(\Delta t) \quad \ldots\ldots (34)$$

Substituting Equations 29, 33 and 34 in Equations 31 and 32,

$$\Delta S = \frac{1+\mu}{2}\left[\left(\frac{b}{b'} - 1\right)(S - D)\right] - (1+\mu)\frac{Z'}{b'} - Ee(\Delta t) \; . (33a)$$

$$\Delta D = \frac{\mu - 1}{2}\left[\left(\frac{b}{b'} - 1\right)(S - D)\right] - (\mu - 1)\frac{Z'}{b'} - Ee(\Delta t) \; . (34a)$$

Since the values of stress on an $S$ and $D$ chart are usually laid out to some suitable scale, the values of $S - D$ may be scaled from the trial solution on the chart and used directly in Equations 33*a* and 34*a*.

The procedure for solving a disk of nonuniform thickness is as follows:

1. Lay out half section of disk and divide it into a suitable number of elemental constant-thickness sections
2. Tabulate the following data for each section
   a. Outside diameter
   b. Velocity $u$ at outside diameter
   c. Width of section $b$
   d. Ratio $b/b'$
   e. The quantity $b/b' - 1$
   f. External loading per inch of circumference at inside diameter of section Z
   g. The quantity $Z/b$
   h. $Z/b$ times $(1 + \mu)$
   i. $Z/b$ times $(\mu - 1)$
   j. $\Delta t$ for each section when temperature differentials exist
3. Lay a sheet of tracing paper over the S and $D$ chart
4. Lay out velocity lines for the values given in step 2b, also for velocity at inside diameter of disk
5. Begin a trial solution by drawing in a trial set of S and $D$ curves between the velocity lines corresponding to the extreme diameters of the first section. Be sure that the initial value of $S - D$ satisfies Equation 29
6. Scale off the final value of $S - D$ for the first section and calculate $\Delta S$ and $\Delta D$ from Equations 33*a* and 34*a*
7. Lay off $\Delta S$ and $\Delta D$ to locate the S and $D$ curves for the next section
8. Draw in these curves and scale off the final value of $S - D$ for the second section
9. Repeat the procedure outlined in steps 6, 7, and 8 for each successive section until a set of S and $D$ curves has been drawn in for each section
10. After two trials, if Equation 29 still is not satisfied for the conditions at the outside diameter of the disk, the final solution for the disk may be obtained by the method explained in the following paragraph.

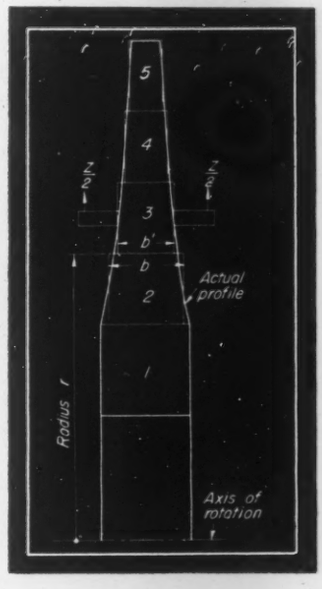



*Fig. 5—Half section of variable-thickness disk divided into sections for sum and difference graphical solution*

In Reference 7 (at end of article) it it shown that for a given disk rotating at a given speed with a known radial stress at its inside diameter, all other stresses will be straight-line functions of the radial stress at the outside diameter of the disk. In the S and $D$ solution of a disk

(*Continued on Page* 186)

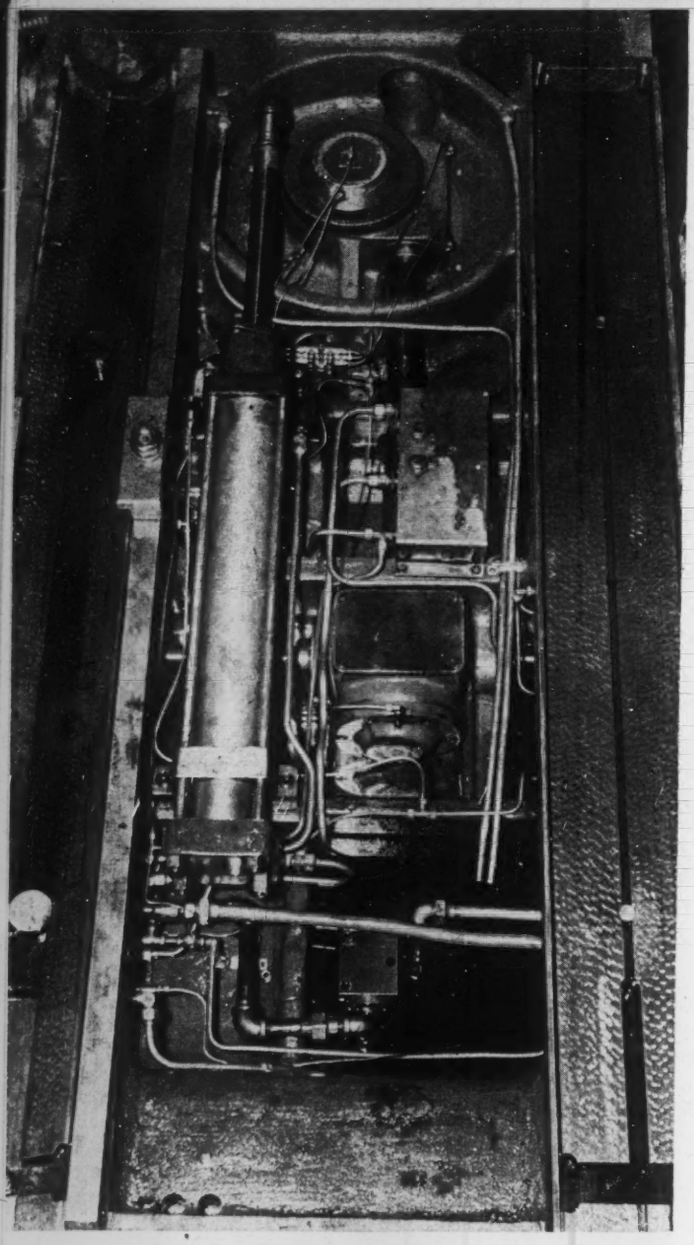
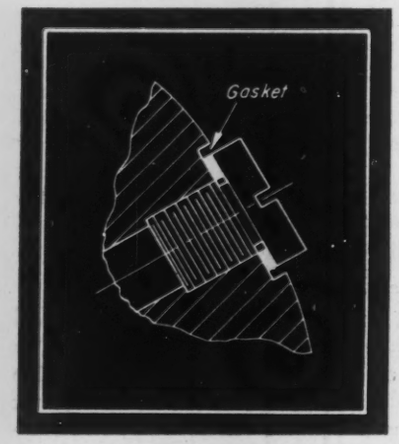


*Fig. 50—Above—Designers of hydraulically operated machines should always question, "How would I like this machine arranged if I had to repair or test it?"*

*Fig. 51—Below—Where appreciable temperature variations occur, elastic gaskets are usually necessary*




# Machine Hydraulics

By Albert H. Dall
*Assistant Research Director*
*The Cincinnati Milling Machine Co.*

## Part VI—Trouble Shooting

DESIGNERS of hydraulic machinery are often called upon to shoot troubles that may develop when a prototype machine is being built. Less often, the designer helps to train repairmen for servicing machines built subsequent to the prototype. In still other instances, the designer has little or no contact with the operation of the product of his imagination. However, even though he should never be called upon to supervise the repair or testing of his machine, *Fig.* 50, the designer should pose this question to himself, "How would I like this machine arranged if I had to test it?"

The reputation of a machine sometimes hinges upon the ease with which it can be serviced. Therefore the viewpoint of the repairman or trouble shooter is highly important and for this reason a review of a few of the typical troubles which are encountered in hydraulic systems may be a relevant addition to this series of articles.

OIL FAILURES: Offhand, it would appear that the designer has little or no control over this type of trouble, except that he specify the correct oil for his machine in the first place. However, some preventive design is possible even with respect to oil failures. Oil contamination of one kind or another is the usual cause of oil failures. The three principal types of oil contamination which cause almost all oil failures are: (1) Oil breakdown or sludging; (2) Foreign material in oil, and; (3) Air in the oil.

Although the better grades of oils have additives to inhibit breakdown, any oil will break down if subjected to excessively high temperatures. Therefore, the designer can do much to prevent these failures by designing for safe maximum temperature of the sump oil, and by eliminating "hot spots" in his circuit. Safe maximum temperatures are attained by using a large oil sump with liberal radiating surfaces. So called "hot spots" are eliminated by minimizing the concentration of energy in spots where the heat is not carried away easily.

Contamination of hydraulic oil by foreign material of various kinds can often be prevented by better guarding of the oil tank and other open parts of the system. This is particularly true on machine tools where cutting fluids are used. Even small amounts of cutting fluid which find their way into the hydraulic system will often accelerate oil breakdown and sludging.

Ingress of air into the oil occurs in two ways, namely, by loose joints in lines of subatmospheric pressure (suction lines) or in loose joints in high-velocity return lines. In the first case the oil will appear to be milky while in the latter case the air will occur in large bubbles. The designer can help to lessen the possibility of loose joints by providing firm support for pipes and tubes which

might otherwise vibrate. Small suction heads help to prevent air ingress, since the negative gage pressure at the pump inlets will be materially increased by the height through which the oil must be drawn.

OIL LEAKS: High-pressure joints should be protected from vibration as well as low-pressure joints. By providing solid mountings, high-pressure joints can be made leakproof permanently and the incidence of failure can be made rare. However, other types of drip leaks can be annoying at times. These leaks are usually found at valves with exposed ends, packing glands and gaskets.

In the case of valves and packing glands, slight leaks are desirable in many cases because the leakage provides continuous lubrication for the moving surfaces. Therefore the designer should make provisions for the leakage to return to the sump rather than be lost outside the machine. Experience has shown that even small amounts of oil on the floor outside the machine are objectionable because it creates a general appearance of untidiness as well as being actually dangerous to personnel.

### Gasketing Method Important

Where gaskets are used, it is necessary to have flat, straight faces in order to prevent leakage or blowout. If metallic gaskets are used, the problem of plastic flow of the gasket must be offset by providing recesses to prevent side flow of the gasket metal. Elastic gasket material is indicated in places where large temperature changes occur since the expansion and contraction will cause permanent set in inelastic materials.

An example of this leakage problem is shown in *Fig.* 51 where a temperature change of 30 F was experienced. With a nonelastic gasket, leakage occurred after each time the temperature changed through its full range. In this particular case, the final solution was a change in design to a pipe plug, since even with elastic gaskets, the requirements for squareness were difficult to fulfill.

TESTING: It would appear that the designer would have only an academic interest in the testing of hydraulic circuits. However, much can be done on the drawing board to ease the work of the tester and trouble shooter. One of the first steps in testing to determine the cause of trouble in a circuit is to apply pressure gages. The designer should make adequate provisions for the gages.

In *Fig.* 52 is shown a hydraulic diagram which incorporates a system of numbers for the various important lines. The trouble shooter must have an up-to-date diagram and it is important that the diagram can be interpreted in terms of the numbers on the drawing. Thus, wherever a lead is taken from a valve block, the block should be stamped with the number corresponding to the diagram. Even at places where plugged holes terminate interdrilling, the number corresponding to the line should be stamped.

A system of this type will not only help the trouble shooter and the user, but is very helpful in testing valve blocks when the machine is being made. Test sheets can be made up for the inspector who can determine with an air hose whether interdrilled holes have been properly joined. These tests are analogous to the bell ringing methods of the electrician. The users of hydraulic machines have indicated that the various lines in a circuit drawing should be colored to facilitate the analysis of circuits. The designer can greatly facilitate the work of the field men by using both colors and numbers.

EXAMPLES OF TROUBLES: It is difficult to generalize on troubles in the field which necessitate design changes. In some cases these troubles are experienced when the user operates the machine in a manner which is different than that originally intended. In other cases, a machine

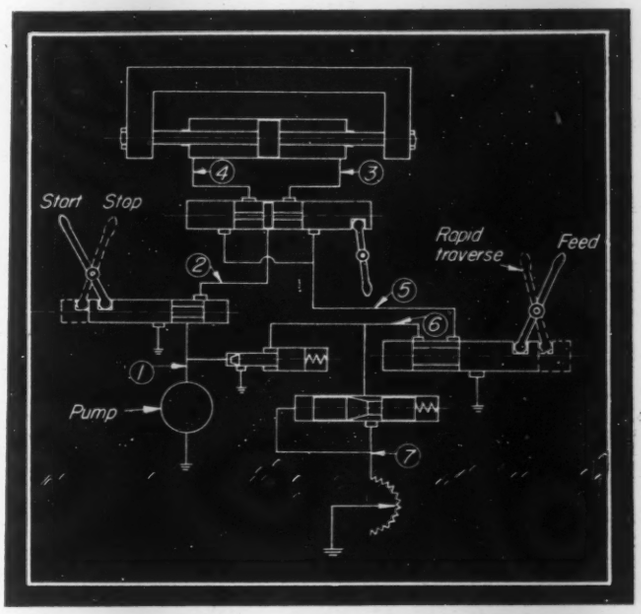
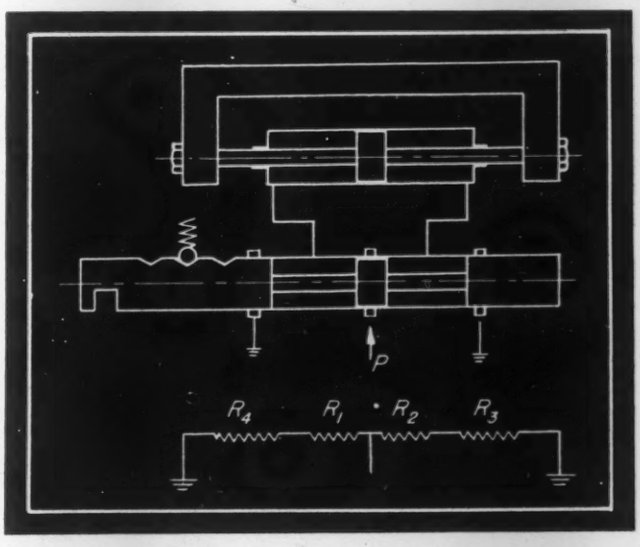



*Fig. 52 — Above — Problems of trouble shooting can be greatly eased by employing a system of line numbering as indicated with this example circuit*

*Fig. 53—Below—Detent positioning shown caused static unbalance and expansion of the high-pressure oil column*




may perform badly after a run-in period, and to make the problem more difficult, similar machines may show no symptoms of this bad performance. The designer is inclined to state that machine X worked very well, therefore machine Y was made incorrectly. While this statement may be partly true, it may be that the critical nature of the design is such that, from a probability standpoint, one in every five machines develops trouble. The system

in *Fig.* 53 shows such an example. In this case, the slide shown was to be held in position while another slide reciprocated. Tolerances on the dimensions of the valve and location of the detent were such that for most of the machines, the static pressure difference at the cylinder due to leakage in the valve was small. On some machines, however, this pressure difference was great enough to approach the amount required to overcome static friction of the slide. Any shock in the system reduces static friction for an instant and at this point the high-pressure column would expand causing a jump of several thousandths of an inch. This jump would be repeated as soon as the pressure built up and another shock was forthcoming. The shock to produce this result was very slight. Since it was impractical to reduce the tolerances on the parts, it was found necessary to make the detent position adjustable.

Another example of faulty hydraulic performance is shown in *Fig.* 54. Here the trouble was not discovered until the user attempted to perform an unusual operation. The slide could be moved by power (throttle circuit) or by hand servo by shifting of a selector valve (not shown).

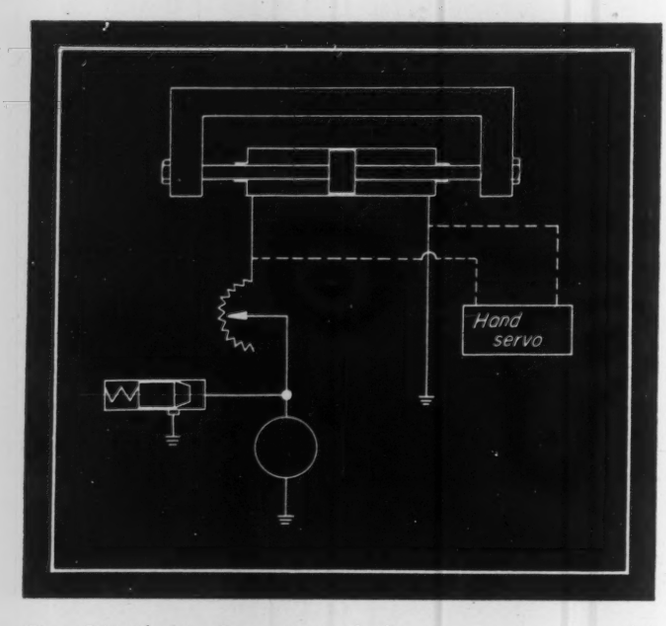
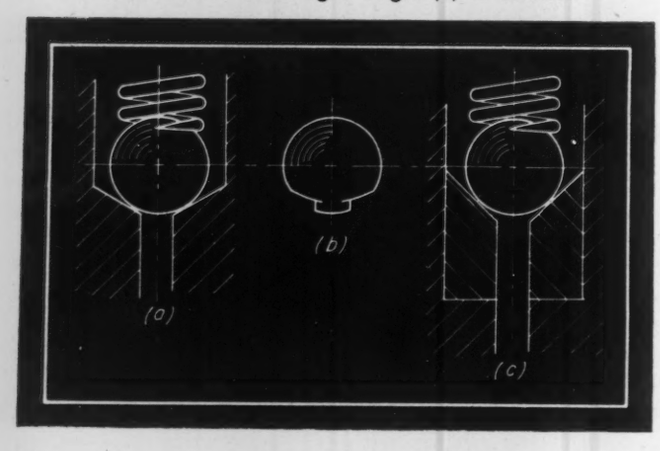



*Fig. 54—Above—Operation of the power servo on this system created appreciable jump in the machine slide*

*Fig. 55—Below—Check-valve ball (a) seats too close to seat edge and will often wear as shown at (b). Design with soft-steel insert and larger angle (c) is solution*




On almost all machines this selector valve is shifted only a few times a day or when the machine is being set up. One user wished to make this shift on every work piece or about three times a minute. Every time the selector valve was shifted from hand to power traverse, the slide would jump appreciably.

Investigation showed that pressure at both ends of the cylinder was about 200 psi when the servo valve was at rest. However, when the selector valve was shifted to power operation, the back pressure dropped immediately to a low value. The required forward pressure for power, however, was 150 psi. Thus, the forward pressure at the instant of change to power traverse was 50 psi in excess of requirements. The forward pressure column therefore expanded to drop the pressure causing a jump of the table. Applying Equation 15, Part III, and assuming $l$ to be 48 inches, we have $\Delta P = 238{,}000\ \Delta l/l$ or $\Delta l = 50 \times 48/238{,}000 = 0.010$-inch.

To overcome this difficulty, the servo valve was redesigned to obtain a pressure balance of 150 psi. This was done by changing the resistances of the valve (see *Fig.* 42, Part V) at the mid-position.

### Check-Valve Design Critical

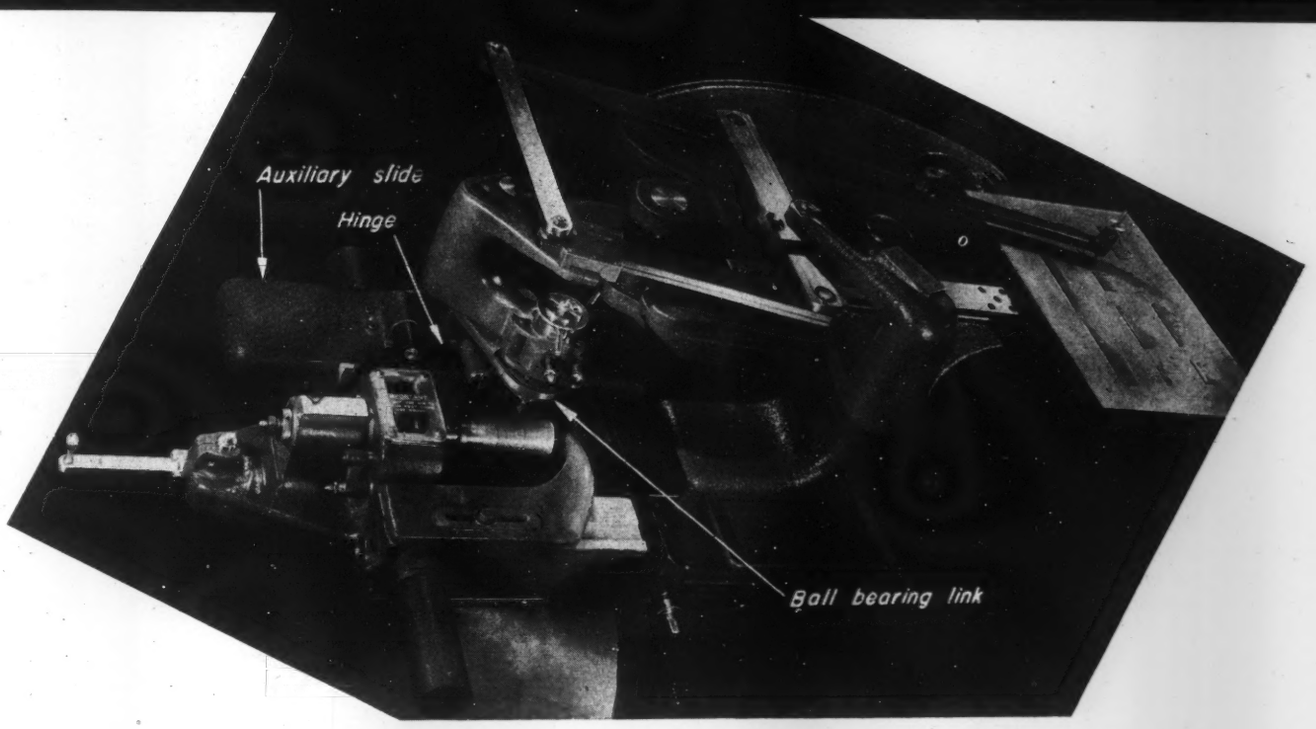
An example of poor performance often encountered when a machine becomes old is that of check valves. Check valves which operate satisfactorily when new may become worn and inoperative in time. In *Fig.* 55 *a* is shown a check valve design which may cause trouble particularly when the valve must operate frequently. Here the ball seats are too near the edge of the hole and if the body material is cast iron, experience has shown that the ball may wear to a shape shown in *Fig.* 55 *b*. The abrasive action of flaked-off cast iron causes this extreme wear even on hardened-steel balls. The cold working and abrasive action on the seat causes the ball to drop until it begins to contact at the edge of the hole.

A commercial type check valve would sometimes solve this difficulty but very often space considerations prevent the use of this type of valve. *Fig.* 55 *c* shows a design solution in which a soft steel insert is used for the seat together with a larger seat angle.

CONCLUSION: The users of all types of machinery are becoming increasingly conscious of maintenance costs. These costs can be minimized in several ways by proper design. By designing the machine in the first place so that failures are not likely to occur, the designer can help materially to decrease maintenance costs. Accessibility and ease of testing will not only enhance the popularity of a machine but will contribute to the economy of operation. (End of series)

### "Mechanical Seals" Series Reprinted

**Because of the numerous requests being received from readers for extra copies of the articles on mechanical seals and their application which appeared in the September to December, 1946, issues, it has been decided to reprint the entire series. The four articles will be published as a booklet under one cover and will be available gratis as a service to readers. Requests for copies should be addressed to: Readers' Service Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, O.—ED.**




# Engraves Cylinders from Flat Patterns

PANTOGRAPH machine, illustrated above, is designed for taking shallow cuts to uniform depths on flat and uniformly curved, convex, concave, or spherical surfaces from enlarged masters in reduction ratios from 1:1 to 100:1.

Originally, when roll work such as character knurls, roll stamps and numbering wheels was done on the pantograph machine it was necessary to employ a forming guide to control the vertical movement of the cutter spindle. The forming guide was made to conform to the diameter of the workpiece and each job of different diameter required a different guide. In addition it was necessary to have many varied styles of circular copy dials or masters. The workpiece was mounted in a suitable indexing fixture, which required a vast quantity of different master indexing plates. Even though this method entailed a sizable investment, the results obtained were none-too-good. The workpiece had to be indexed for each group of two or three characters depending on size and style and the master likewise had to be indexed. On a job having 50 or more characters this represented considerable time with many possibilities of error.

In view of this situation, the George Gorton Machine Co., Racine, Wis., developed a completely self-contained fixture for its pantograph machines. Called a roll attachment, it entirely eliminates the need for forming guides, indexing plates, special masters and manual indexing. The attachment is coupled to the machine at the lower end of the cutter head with a ball-bearing link and hinge which positions the cutter exactly above the axis of the workpiece at all times. Tracing or guiding the stylus around a flat-master pattern or template transmits motion, in reduced proportion, through the pantograph bars to the roll attachment.

When the tracing stylus is moved along a line parallel to the axis of the workpiece no rotation takes place. This is because the cast-aluminum auxiliary slide to which the cutter head is coupled does not transmit motion to the cast aluminum carriage supporting the work. The workpiece therefore remains stationary while the cutter moves along the axis. This auxiliary slide is mounted on V-type ball bearing ways running parallel to the axis of the workpiece.

When moving the tracing stylus at right angles to the axis, motion is transmitted through the pantograph bars by means of the ball-bearing link, hinge and auxiliary slide. This moves the work-holder carriage which is also mounted on V-type ball-bearing ways running at right angles to the axis of the workpiece and rotates the workpiece.

Movement of the work-holder carriage rotates the work beneath the cutter by means of a steel band which rides, under tension, on two ball-bearing idler pulleys and over the work-holder spindle pulley. The steel band, idler pulleys and spindle pulley are contained in the work-holder carriage. The two ends of the steel band are fastened to each end of an actuating bar enclosed in the tubular housings on each side of the work-holder carriage.

By setting the graduated, adjustable scale which extends to the left of the work-holder carriage, to correspond with the diameter of the workpiece and proportioning the master pattern or template to coincide with the pantograph reduction ratio, cylindrical milling, profiling, grinding, engraving, or electrical etching around a periphery is accomplished as easily and as accurately as on flat work.

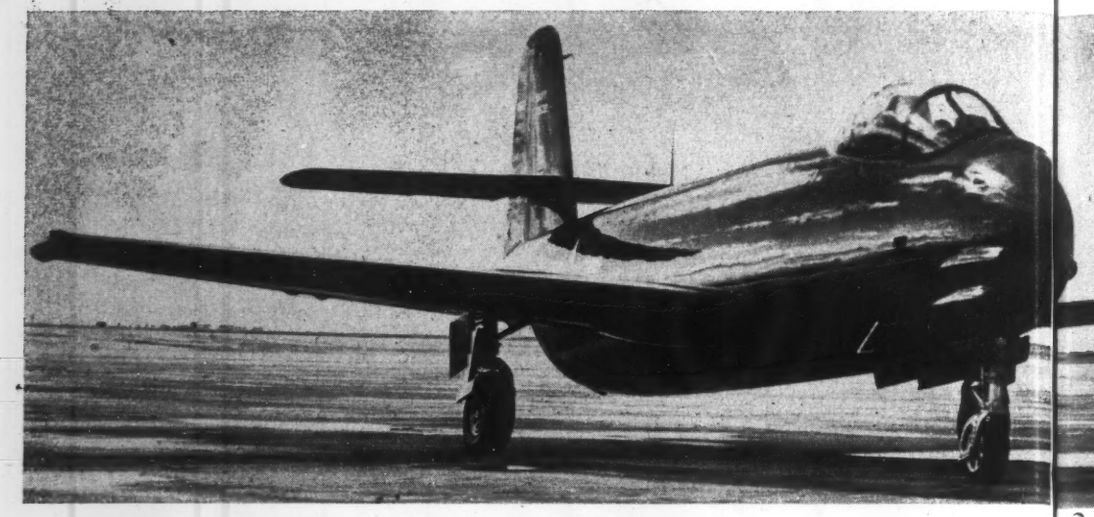


*Fig. 1 — Jet-propelled Navy fighter, the XF6U-1, on which 95 per cent of the structure is metalite, a metal-faced, balsa-core sandwich material*

# Sandwich Materials

NOW in the stage of practical use, *Fig.* 1, sandwich materials hold great promise for a variety of future applications requiring light weight combined with high strength and stiffness. At the recent S.A.E. annual meeting in Detroit the characteristics of such materials were discussed in a series of three papers, abstracts of which are presented on this and the following pages.

## Metal Faces with Honeycomb Core


### By W. W. Troxell and H. C. Engel

*Glenn L. Martin Co.*
*Baltimore*


SANDWICH construction involves a face material which carries the major applied loads, a core material which stabilizes the faces, and a bonding medium which effectively fixes the faces to the core under all service conditions. The relative effectiveness of various sandwich materials is determined by the particular application, the nature of core and face materials, the ratio of core to face material, and the nature of the bonding medium.

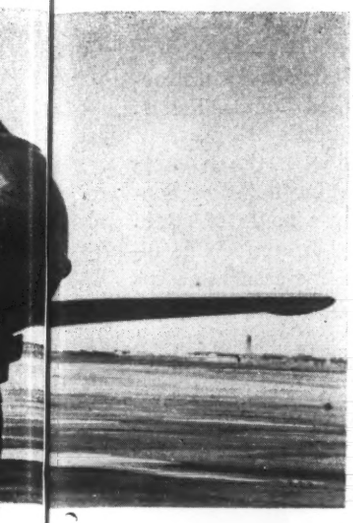
At the present time only two core materials, balsa wood and honeycomb, are structurally employed to any noteworthy extent. Several other materials, including cellular cellulose acetate, may come into wide usage. Without attempting to select either balsa wood or plastic honeycomb as the most efficient core material, for either may be superior to the other in certain specific applications, it may be well to review some general advantages and disadvantages of each.

Balsa wood, having a relatively high strength-weight ratio, is capable, under certain conditions, of bearing a proportion of the load applied to the sandwich structure. Being a continuous medium it is capable of stabilizing very thin face sheets. For the same reason, the problem of bonding faces to core is not severe. However, the resistance of balsa wood to moisture, decay, fungus, and fire is rather low; it is nonuniform, requiring careful selection before use in most structural applications, and, not being available in large slabs, it presents handling and fabrication problems.

The honeycomb type of core, supporting the faces of the sandwich discontinuously, allows premature panel failure if the faces are thin and the cell size too large. Its discontinuous surface magnifies difficulties involved in bonding the faces to it and it is incapable of bearing any share of loads applied in the plane of the panel. Because it is formed of dense impregnated fabrics or papers, its flame and water resistance is relatively good and it is not easily attacked by fungus, decay, etc. Being a manufactured product, honeycomb is uniform in specific gravity and properties and can, within rather broad limits, be tailored to fit a given application or given price by varying its component materials and its cell size.

This article is confined to a discussion of sandwich constructions having 24S-T Alclad aluminum alloy faces and a particular type of honeycomb core, the structure being bonded by one particular adhesive. The honeycomb core material, *Fig.* 2, is formed of 4-ounce cotton sheeting which contains approximately 45 per cent phenolic resin. Its cell walls are about 0.009-inch thick and the diameter of its inscribed circle is about 0.43-inch.

The honeycomb core can be produced in blocks or slabs which may be sliced or contoured to the desired shape



and size, or it may be made in flat form, i.e., a series of sheets bonded together in a fashion which upon expansion produces a honeycomb structure. Contouring, shaping, etc., of the flat type honeycomb is sometimes desirable, in which case the required shape develops after expansion. Honeycomb, thereforefore, lends itself to both conventional sandwich construction and to constructions in which the honeycomb forms the bulk of a given structure but is covered by a metal or other skin, such as in an airfoil section having a complete honeycomb core.

Plycozite adhesive (U. S. Plywood Corp.) was specially developed to fulfill the bonding requirements of honeycomb constructions after preliminary studies proved that commercially available adhesives were inadequate, especially with respect to creep and toughness. It is, in its cured state, characterized by substantial insolubility in all organic solvents and unusual strength under either shearing or tensile forces.

For practical gages of metal and depths of overlap (metal ⅛-inch thick or less and laps of 0.5-inch width or more) failure in the glue line takes place when the stress in the metal is approaching ultimate; that is, the failure of the adhesive is determined by the elongation of the metal. For example, in double lap tension shear specimens of 24S-T Alclad, all specimens tested failed when the alloy was stressed above 54,000 psi—regardless of the metal thickness, depth of lap, etc. Immersion tests (water, engine oil, aromatic fuel, etc.) and salt spray tests have indicated no significant strength reduction in metal-to-metal bonds after exposures in excess of 1000 hours.

Flexural failure of relatively long panels generally results from buckling of the face on the compression side of the specimen. Very short spans produce shear failure as would be expected. Its high ratio of flexural stiffness and strength to weight makes the sandwich type of construction useful in many applications. With given face and core materials, the stiffness-weight ratio and strength-weight ratio depend on the ratio of face thickness to core thickness. As the face thickness increases, the panel becomes stronger and stiffer, but also heavier. The most efficient design is obtained at a certain optimum face-thickness ratio.

Well bonded panels loaded in compression in the plane of the faces show three primary types of failure: (1) Instability as a column (Euler type failure); (2) Buckling of face sheets into the honeycomb cells; (3) A short wavelength wrinkling of the face sheets, usually referred to as "wrinkling failure." The failing stress (i.e., the load divided by the cross-sectional area of the faces alone) depends on the slenderness ratio, the ratio of face thickness to total thickness, and on the ratio of face thickness to honeycomb cell size.

A comparison of the strength-weight ratio of metal-faced honeycomb core sandwich panels of all-metal construction shows that the sandwich of optimum proportions is somewhat less efficient as a column than a well-designed zee-stringer and sheet combination. This comparison of panels supported only at the ends, however, ignores the advantage possessed by the sandwich construction by reason of its transverse stiffness. The fact that it has stiffness in both the longitudinal and transverse directions makes the sandwich type particularly suited to panels of nearly square dimensions and those which are relatively long parallel to the direction of loading and narrow transversely. Weight saving due to elimination of supporting ribs and transverse formers is a large factor in favor of the sandwich construction.

Since no stiffeners are used with sandwich webs, "tension field" action cannot develop. As soon as buckles appear, the whole panel fails suddenly. The elastic stability of the web is thus the determining factor.

In structural applications of sandwich materials, periods of sustained loading must often be anticipated. In some cases service cycles consist of periods of high load alternating with no load. Under such circumstances the creep characteristics of the material employed may control the design. Investigation has shown that all sandwich materials exhibit, to a greater or lesser degree, creep phenomena, in some cases failing in the core or adhesive layer in surprisingly short times under relatively low sustained loads.

Various tests after exposure to high humidities and low and high temperatures all indicate that in the interests of conservative design, properties determined at room temperature should be corrected 10 to 15 per cent to allow for all conditions encountered in aircraft service. Care should be taken to close off all edges with a strip of metal, plywood, or other material, and to seal them so as to exclude moisture.

The earliest applications of honeycomb constructions have been, as would be expected, in aircraft installations where a premium could be paid for weight saved. Miscellaneous doors and sections of flooring installed in both land and sea-based aircraft are, according to latest service reports, performing adequately. Currently, extensive use of honeycomb constructions is being made by most aircraft manufacturers. Floors, doors, partitions, shelves, bulkheads, and wing ribs are already installed in both new and reconverted planes.

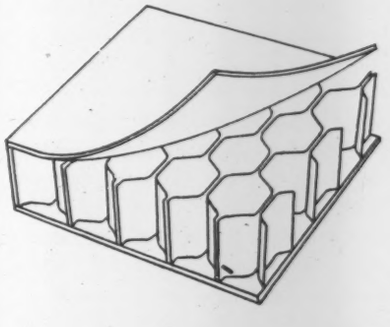


*Fig. 2—Construction of metal-faced, honeycomb-core sandwich material*

In addition to conventional sandwich structures, where faces are parallel and the core of constant thickness, honeycomb may be used as a contouring filler in wing and similar construction. In such cases the metal skin must

be formed and the core accurately shaped before bonding.

It is expected that nonaircraft applications of honeycomb constructions will be numerous. Design and construction of honeycomb units are underway in various fields. Experimental houses, trailer bodies, railroad cars, shipping containers, furniture, and other items are being constructed.

## Metal-Faced Balsa-Core Material

By H. B. Gibbons

*Chance Vought Aircraft Div.*
*United Aircraft Corp.*
*Stratford, Conn.*

TO BE suitable for general use in high-performance-aircraft construction, the sandwich must compete on a strength, stiffness, and weight basis with the highly efficient all-metal construction of present-day aircraft, hence the combinations which can be used successfully are extremely limited. Chance Vought has concentrated its efforts largely on one, a metal-faced balsa-core combination which has been given the tradename "Metalite". In the interest of efficiency, the faces normally are made of high-strength aluminum alloy, the core being low-density balsa wood arranged as shown in *Fig.* 3 with the grain of the wood normal to the metal faces. A two-stage bonding operation is employed. In the first stage Cycleweld C-3 cement is cured on the metal faces only. Final bonding of the faces to the core is accomplished with a medium-temperature phenolic-resin adhesive.

Broadly speaking, the accomplishments with this material to date have been as follows: Two distinct types of experimental naval aircraft in the high-speed fighter category have now been built with the major portion of the airframe constructed of this type of sandwich; also, an experimental production contract involving two hundred sets of stabilizers for the F4U Corsair airplane has been completed successfully.

Many considerations led to the decisions to adopt this form of construction for these projects. It was realized in the beginning that construction in sandwich form is essentially a molding operation in which the possibilities of obtaining smoothness for an exterior surface are inherently good, even the extreme smoothness and fairness required for truly low-drag airfoils. This was an attractive possibility, considering the improvement to be gained in performance of the airplane and also the fact that it is quite impracticable to obtain this degree of smoothness with conventional construction. Furthermore, sandwich construction promised the elimination of buckling and other forms of distortion in highly-loaded aerodynamic surfaces. This construction also permitted a simplification in design and a considerable reduction in the number of fabricated parts, such as stiffeners, frames, and clips.

First major structural use of Metalite was in the XF5U-1, an unconventional high and low-speed Navy fighter airplane designed particularly for carrier operation. Metalite was used for more than 75 per cent of the airfoil surface and nearly all of the internal shear webs. The entire external surface is doubly curved, this surface being composed of a number of separate panels bolted to the internal framework. Nearly all the panels were fabricated without preforming the metal faces, the forming being accomplished in the molding operation.

Metalite has been used also in the design and construction of a more conventional, jet-propelled fighter, *Fig.* 1. In this airplane, the XF6U-1, approximately 95 per cent of the entire structure was made of sandwich, the movable control surfaces being the only important items of conventional construction. Every effort was made to attain smooth, aerodynamic surfaces, resulting in appreciable increase in high speed and a significant increase in radius of action, due to the lower drag which reduces fuel consumption at cruising speed.

In the first attempts, the balsa wood was arranged with the grain of the wood parallel to the face sheet in an effort to utilize the strength of the wood in the direction of the grain. It was soon found, however, that a more advantageous arrangement could be obtained by placing the grain normal to the faces. The loss of with-grain balsa

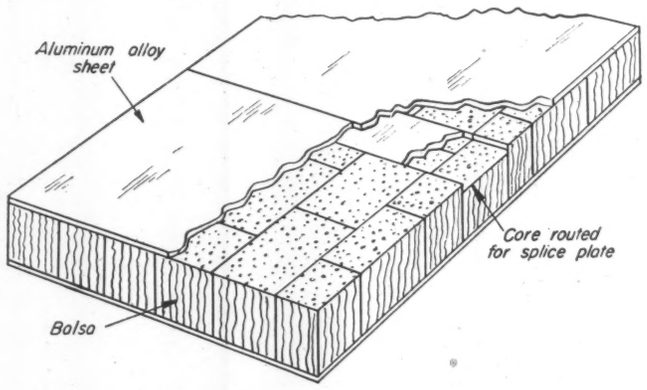



*Fig. 3—Arrangement of balsa core in Metalite sandwich, showing bonded splice by means of which large face widths are obtained from standard-width sheets*

strength was more than made up by the increase in strength obtained from the faces due to the considerable increase in stabilization afforded by the normal grain. In addition, the sandwich now became a much more desirable material for design purposes since it has practically uniform tensile and compressive strengths in all directions; the end grain balsa core had excellent forming characteristics, and sealing the ends of the balsa fibers decreased the amount of moisture absorbed to insignificance.

As can readily be imagined, the design of an airplane structure of Metalite introduces numerous problems that are peculiar to sandwich type construction. It should not be inferred that designing with Metalite is more difficult. Rather, it has been the experience that the design problem as a whole is simplified for the majority of the applications. For any large-size structure, such as a wing or fuselage, the structure is designed and fabricated as a number of separate components, the components being joined together by fairly conventional means, such as rivets or bolts. In laying out any design, two major factors must be considered in the division of the structure. One is the assembly procedure to be followed and the other is the limit on the size of the parts which can be handled by the production equipment. Because of the limited widths in which the thin-gage aluminum sheets are available, it is often necessary to splice the faces. This is

accomplished with high efficiency by means of the bonded joint illustrated in *Fig.* 3.

In making a stress analysis of a Metalite structure, it is obvious that the bending stiffness of the shell cannot be neglected as it has such a marked influence on the stress distribution. Because the stiffness of the end-grain core in the direction parallel to the faces is low and nearly uniform, the planar and bending properties of the complete panel are virtually constant in all directions. Therefore, the theories for the elastic behavior of isotropic plates and shells can be applied to Metalite by determining the thickness and modulus of elasticity of an equivalent simple plate or shell.

Apart from the problem of determining the stress distribution in the structure is that of determining the allowable stresses not only for uniaxial stress, but for all combinations of biaxial stress. For the most part, these have been obtained from experiment, but enough theory has been developed to give us a basic understanding of the problem and the factors which are of the greatest influence. Failure of the faces in Metalite may occur either through rupture or local wrinkling. In general, the use of end-grain balsa as a core material permits the development of face stresses above the yield point of the material in compression and shear. The thickness of the face has little effect on these allowables. Compressive stresses well above 80,000 psi have frequently been attained in Alclad 75ST and R-303T sheet material even with the thinnest gages available. Values above those normally accepted for the shear ultimate of the face materials are oftentimes attained in practice. The development of face stresses well above the yield point of the material is significant to the structures designer, not only because of the high strength efficiency indicated, but because of the ability to absorb high local strains. This characteristic is important in lessening the effect of stress concentrations and allowing a simplification of design.

Although it is believed that Metalite is generally the most suitable type of sandwich material for an aircraft structure, there are specific applications where this type is definitely not the best. For instance, nose hatches, tail cones, and wing tips are items having considerable double curvature. If it is expedient to make these items of sandwich construction, a different face and core material is preferable. Such items have been constructed for Vought using fiberglas face material and a hard foamed rubber core. The excellent formability of these materials and the not too severe strength requirements make this combination attractive.

# Design of Sandwich Structure

By John F. Korsberg

*Boeing Aircraft Co.*
*Seattle*

ELEVATION of sandwich-type structure from the role of experimental application to one of practical importance is not so much the inception of the efficient material distribution as it is the progressive development of newer and more reliable adhesives which are capable of providing a strong bond between core and face panels. The ultimate goal in all sandwich-type panel design is to develop the ultimate shear strength of the core material without failing the bond. Thus the characteristics of the core material can be matched with the design requirements to best weight advantage.

Normal reaction of the average engineer confronted with the proposal to use sandwich-type structure is one of uncertainty and reluctance on his part to affix his approval to a structure the quality of which is so indeterminate by conventional methods of examination. The Boeing Aircraft company was confronted with this problem when sandwich-type structure was first contemplated, and the meager quantity of test data then available served only to arouse our interest. In order to justify a decision to specify this new material, an extensive static and fatigue test program was conducted wherein the material was subjected to extremely rigorous accelerated test conditions to prove that even under the most adverse condition anticipated, the material would continue to work as a homogeneous body.

## Metallic versus Nonmetallic Faces

For some parts, nonmetallic sandwich-type panels prove more economical from a weight standpoint than the metal-faced sandwich. These applications are, however, relatively infrequent on our large aircraft and occur only where the optimum gage of aluminum alloy face panels is below that readily obtainable. The low values of modulus of elasticity and ultimate strength are contradictory to the basic purposes for using sandwich structure. A few applications of paper-faced, plywood core, sandwich material were incorporated in our production designs before aluminum alloys became more readily available, but recent designs have veered sharply toward the aluminum-alloy face material which we have found to be the optimum combination in most cases.

Selection of the core and face panel combination is an important detail worthy of careful consideration, maximum efficiency being attained from a panel which is sufficiently strong yet does not have too high a margin of safety. Contrary to first impression, selection of the panel combination is not the major problem in sandwich-type structural design; a great deal more time is consumed with the development of practical fitting details which will give adequate static and fatigue strength while preserving reasonably practical and economical shop fabrication procedures. *Fig.* 4 illustrates some of the fittings which have been found useful with the honeycomb core as well as the balsa-core sandwich panelling. Each fitting has its particular characteristics and only by analysis of the design conditions to be met can the proper fitting be selected. All the fittings in the figures have been used on both balsa-core and honeycomb-core panels with exception of the countersunk screw, *Fig.* 4 (*b*) and (*c*). Use of the screw without a spacer in the honeycomb-core panels has been unsatisfactory because in all cases a supplementary fitting is required to react to the local compressive loads attendant to drawing the screw flush with the panel face. When riveting, of course, both types of panelling require radial restraint for the rivet shank to prevent local buckling and permit formation of a full driven head, *Fig.* 4 (*e*), (*f*) and (*g*).

When installing flush fittings, the best in appearance and strength is attained by spin dimpling the countersunk

recess. Fittings can be drawn in by using an oversize hole to prevent cracking of the top sheet but this method, while good for production, does not give as workmanlike an installation as when the recess is spun prior to installing the fitting.

When working with large panels, one is nearly always confronted with the necessity of making a splice to overcome limitations on size imposed by manufacturing facilities. Since good appearance or aerodynamic smoothness demands flush joints, the conventional butt joint with splice plates may be applied quite simply, *Fig.* 4 (*h*). In many cases the splice plates can be integrally bonded to the basic face panels, providing superior joint strength, weight economy and saving in assembly time, *Fig.* 4 (*j*). Final assembly of the joint may then be made by using a countersunk grommet and forming the driven head of the rivet into the countersunk recesses, producing a flush joint.

To attain identical shear load capacity it is necessary to construct the honeycomb-core sandwich thicker than the balsa-core sandwich. From a static strength-weight and stiffness standpoint, the honeycomb core will then give superior performance over that of the balsa, and since the material is a manufactured product with all components closely controllable, the honeycomb core will provide the most consistent product.

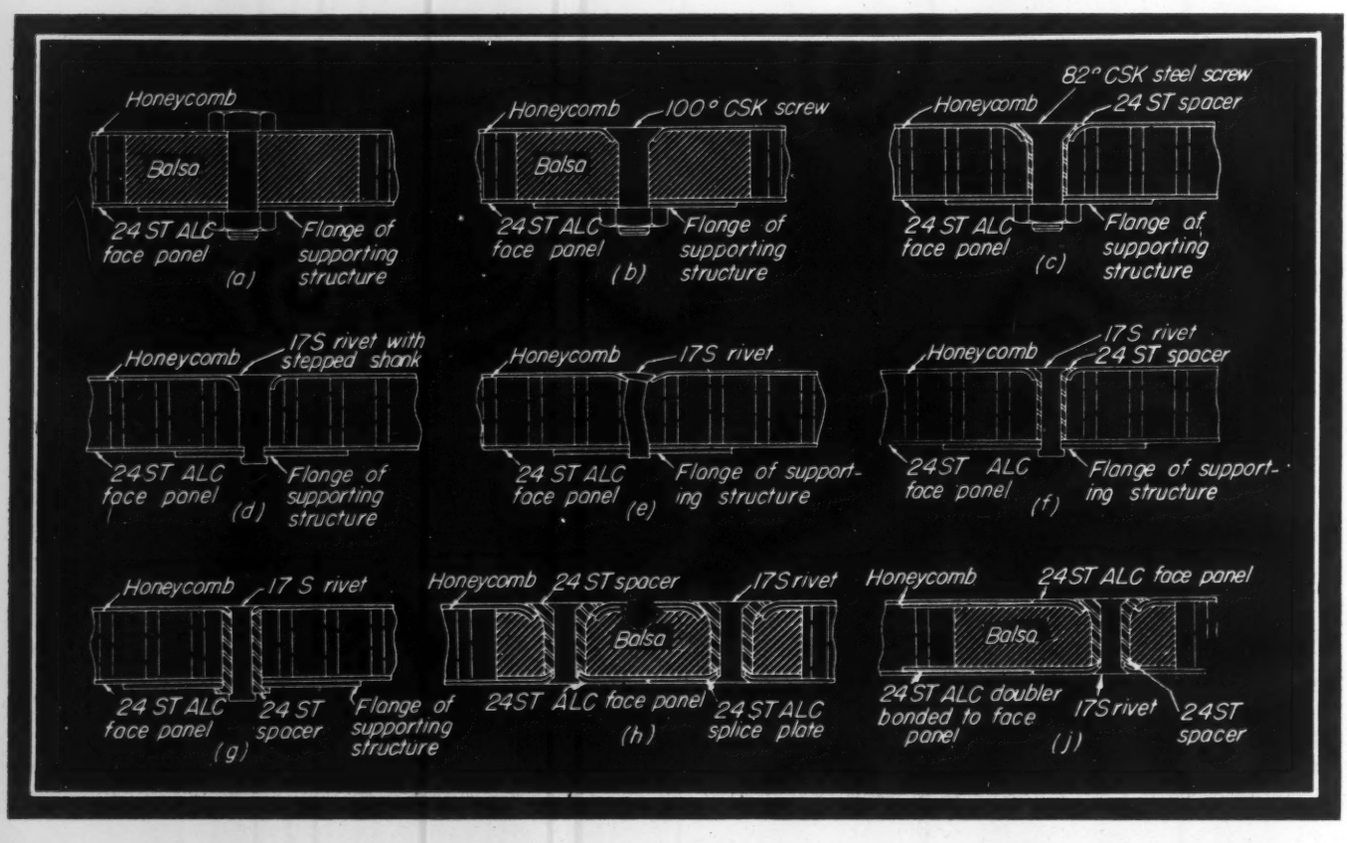
Fatigue resistance characteristics assume a somewhat different trend. Our experience has been somewhat better with the balsa-core material than with the honeycomb-core material. Apparently, both the greater bond area and superior elasticity of Cycleweld cement promote good fatigue characteristics by discouraging local concentrations which are the forerunners of fatigue failures. The foregoing statement has been repeatedly corroborated in our laboratories notwithstanding the greater unit strength of the adhesive used in the honeycomb core sandwich. The unit strength of adhesive bond becomes of secondary importance when working with lightweight core materials because the best strength obtainable is governed by the strength of the core material.

For some load conditions, where local crushing strength for loads applied perpendicular to the plane of the panels are critical, the balsa core material is the logical choice. Its crushing strength over 1 square inch area is nearly twice that of the honeycomb-core material (2700 pounds and 1500 pounds respectively).

When working with aerodynamic surfaces, panels necessitating second-degree curvature usually enter the picture and, unfortunately, metal skins are not receptive to second-degree curvature without some preforming operation on the stretch press. Some sacrifice in structural efficiency is inevitable over the ideal metal sandwich by specifying fabric-faced sandwich which will work effectively for surfaces with curvature in two directions. Assembly fittings become very troublesome in the nonmetallic sandwich but judicious use of local inserts and metal doublers usually results in a reasonably reliable and simple-to-make fitting detail.

Little data are available establishing the column and crushing characteristics of balsa-core, metal-faced sandwich material but available statistics indicate allowable stresses for the balsa-core material somewhat higher than those for honeycomb-core, metal-faced sandwich. For most structural applications, however, the honeycomb-core sandwich will prove the most efficient, providing of course, fittings can be made adequate for the required design loads and the special characteristics of balsa core are not mandatory for the proposed application.

***Fig. 4—Typical methods of fastening sandwich-type material to the supporting structure***



MACHINE Editorial DESIGN

# Edison's Tenet—Is It Needed?

*Engineers responsible for the design of machines, whether or not they possess a particularly inventive turn of mind, cannot fail to benefit from a study of the career and methods of Thomas A. Edison, the hundredth anniversary of whose birth recently was commemorated. Holder of more than a thousand patents, Edison has been acclaimed as the greatest inventor the world will ever see. Certainly it is unlikely that in the future there will be the opportunity for any man, through genius and intuition, to produce as diversified and successful a range of developments as did "The Wizard of Menlo Park".*

*Early in life Edison learned the value of not spending time on any seemingly wonderful creation of his mind unless there was a definite need for it. One of his early patents covered a vote recorder which at that time he believed would solve the problem posed by inaccurate counting of votes. Journeying to Washington with his perfected machine, he found to his disgust that it was unsuitable for the purpose intended and he thenceforth determined to direct his future efforts along lines more reasonably assured of success.*

*Many as were the scientific discoveries credited to Edison, he was jeered and scoffed at by scientists of his day. Yet he never looked backward nor lost heart. It would be impossible to detail the multitude of devices he went on to perfect in addition to his far-reaching developments in the fields of telegraphy, lighting, voice recording and reproduction, and moving pictures.*

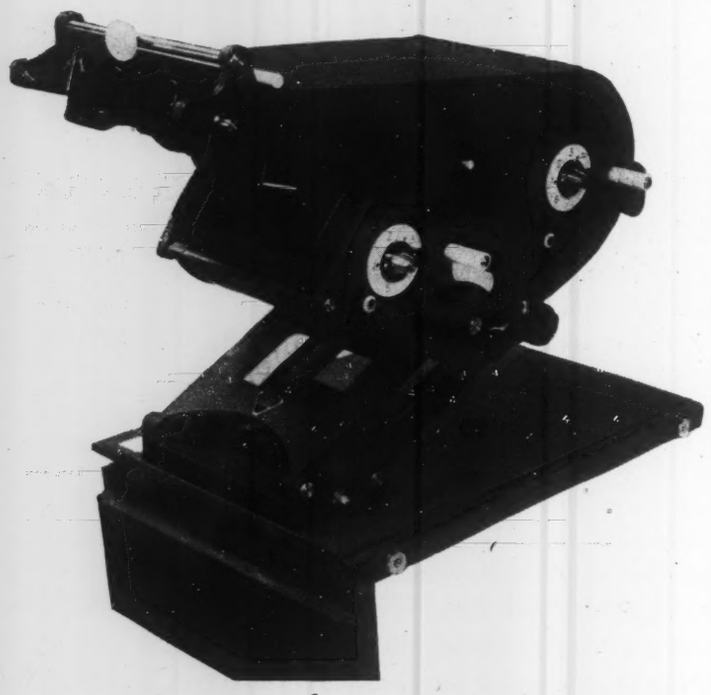
*One of the primary reasons for the great inventor's accomplishments, apart from his innate common sense, was his establishment of research laboratories in which to carry out his experiments and bring his creations to the marketable stage—the forerunners of today's great industrial and commercial research laboratories. Further, Edison combined the relatively rare gifts of invention and practical application to a degree that might well be accepted as an effective criterion by many present-day engineers and designers.*

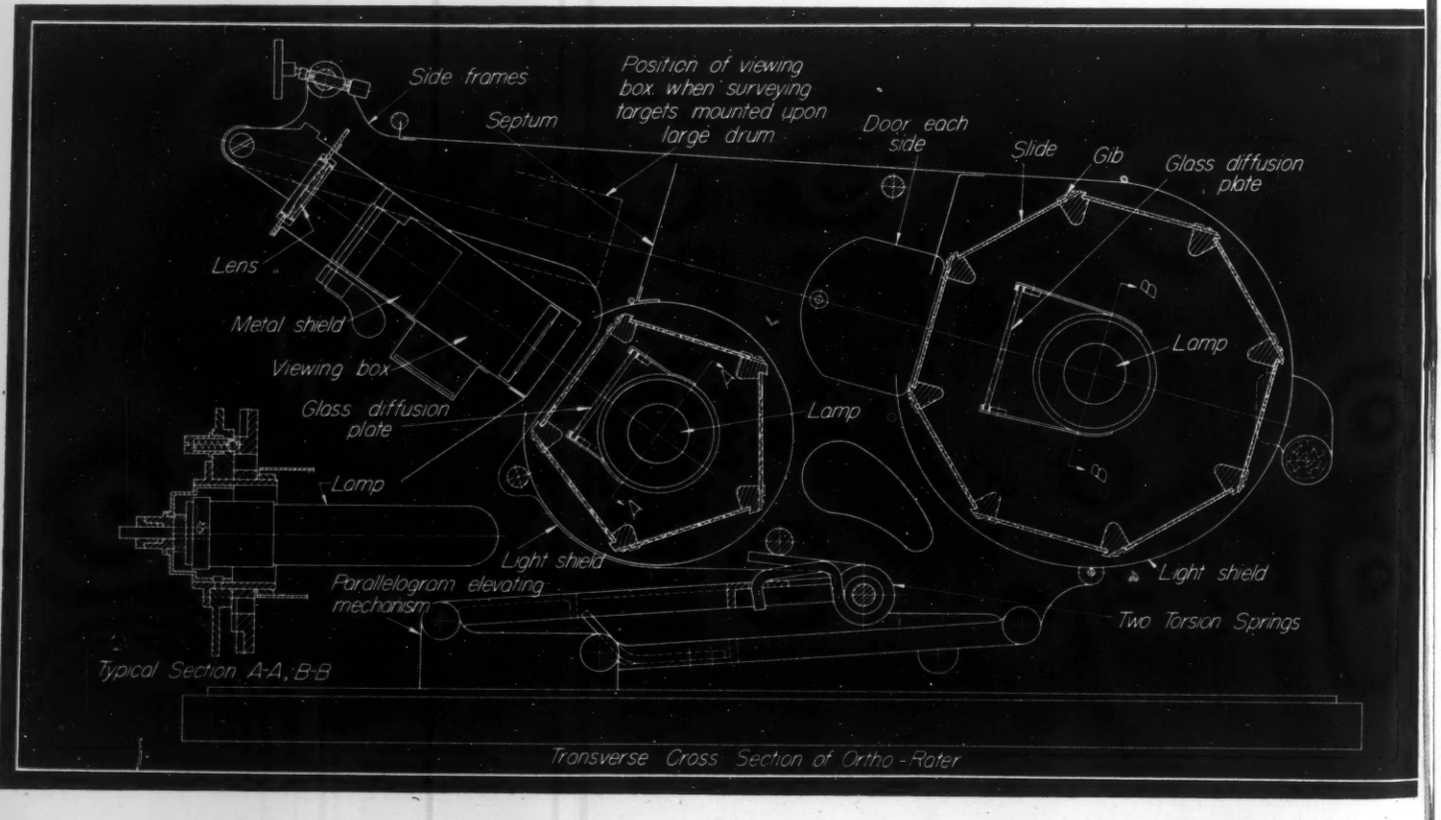
L. E. Jermy

# DESIGNS OF THE MONTH

## Modified Stereoscope Measures Visual Skills

THIS instrument, known as the Ortho-Rater, is used for rapid and accurate measurement in visual skills. Essentially it is a Brewster stereoscope modified and adapted for use in industry. The targets, or stereograms, are mounted on rotatable drums and the target area illuminated from a lamp with the light diffused by solid or flash opal glass plates. These targets are viewed through a pair of lenses, the separation between the lenses and targets being such as to locate the image formed by the lenses at the proper distance from the subject.

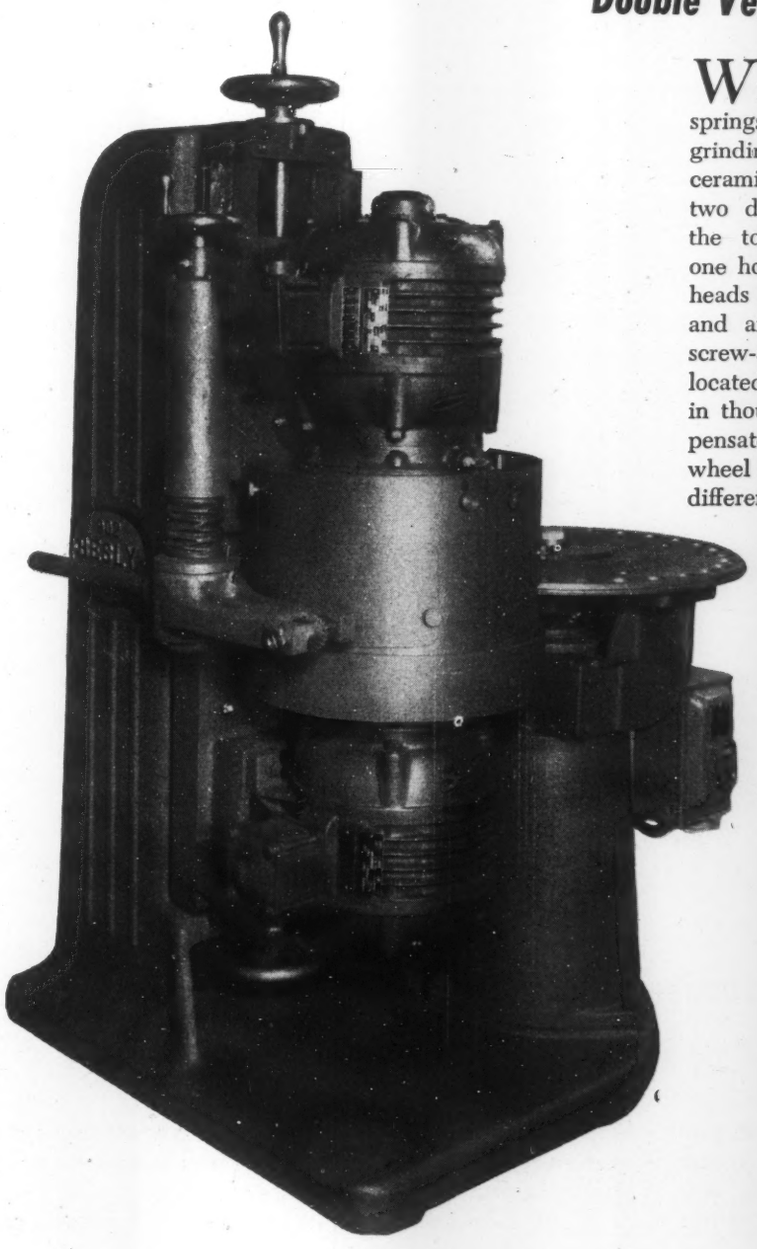




Lenses are mounted in the end of a viewing box which can be swung about a horizontal axis passing approximately through the axis of rotation of the eyes. When in the upper position, the viewing box allows for observation of the distant targets, and in the lower position brings the near targets into the field. This change is necessary since the postural set of the eyes has some effect on the measurements. Either eye can be occluded by a metal shield operated by a handle below the viewing box. The lower edge of each target slide rests in a groove accurately milled parallel to the axis of drum rotation and the upper edge of each slide is held by a gib. Viewing lenses in the mount can be rotated in assembly so that the base apex line of the lens prism is properly aligned. After they are adjusted, the lens mounts are pinned for permanent positioning.

Entire body of the instrument is mounted on a parallelogram elevating mechanism to permit height adjustment, weight of the main body being counterbalanced by two heavy torsion springs. This mechanism is locked at the adjusted height by a split clamp acting on the axle of one of the parallel arms. Entire instrument is mounted on a wood base that is also the bottom of the carrying case. Manufacturer: Bausch & Lomb Optical Co., Rochester, N. Y.

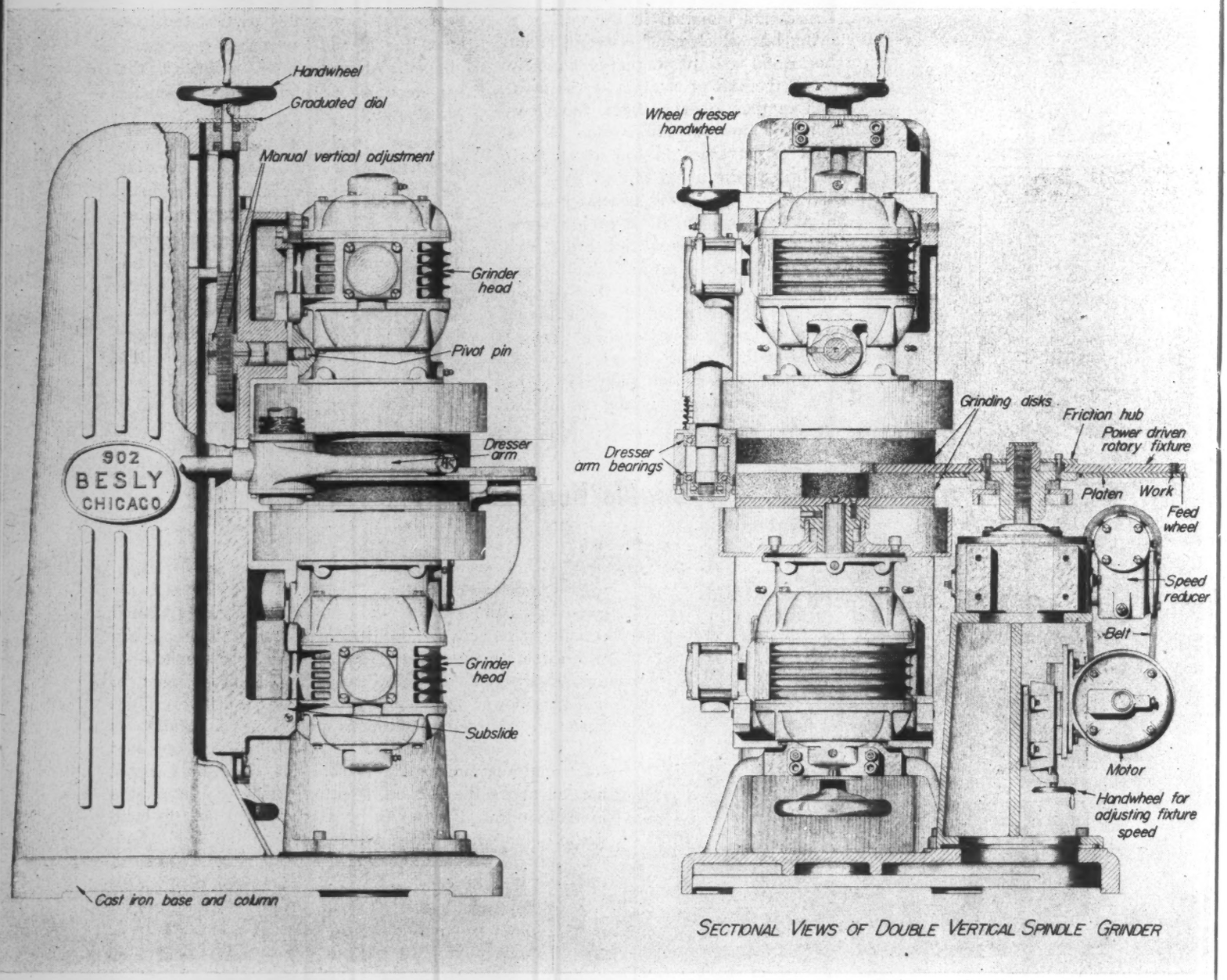
## Double Vertical Spindle Grinder



WHILE designed primarily for the grinding of helical springs to length, this machine also can be used for grinding small rollers, washers, carbon brushes, small ceramic parts, etc. The cast iron base and column carry two direct motor-driven grinder heads, each motor—of the totally-enclosed ball bearing type—being rated at one horsepower and running at 1750 rpm. These grinder heads are mounted on subslides with gibbed dovetail ways and are adjusted vertically by means of hand-operated screw-and-nut units. Handwheel for the upper head, located above the column, is fitted with a dial graduated in thousandths. The lower head is adjusted only to compensate for wheel wear, whereas the upper-head handwheel is used when adjusting the wheels to take care of different lengths of work and when opening the wheels to permit truing them. Adjusting screws for both upper and lower heads are located inside the column away from grit and grindings, and are equipped with ball thrust bearings.

Each motor-driven head is attached to its subslide with cap screws and positioned on the slide by a pivot pin located beneath the wheel collar. Two horizontal set screws near the rear end of each spindle motor permit adjustment of the head laterally. Two shims located near the front or wheel-collar end of each head and two set screws —which rest on hardened steel buttons and are located at the rear of each motor—permit adjustment to and from the subslide. Thus, the heads are adjustable in every direction, a feature required to permit progressive grinding of the work as it is carried by the rotary fixture between the two grinding disks. The truing device is hand operated and is attached to the left-hand side of the upper subslide, the dresser arm being mounted in large ball bearings. Position of the dresser cutters is controlled through a screw and handwheel as shown.

The power-driven rotary fixture is mounted on a cast iron pedestal which supports a 900-to-1




SECTIONAL VIEWS OF DOUBLE VERTICAL SPINDLE GRINDER

reducer driven by a ¼-hp, 1160-rpm motor through a variable-speed pulley and belt unit. Feedwheel of the fixture is mounted on a friction hub attached to the reducer output shaft. In the event the work fouls as it is about to enter the grinding zone, the feedwheel will stop rotating. Feedwheels generally are of the solid type with suitable holes drilled to accommodate the parts being ground. Work is supported in the loading zone by a nonadjustable, semicircular platen under the feedwheel. Upon emerging from the grinding zone the work is free to drop out into a tote box or any other apparatus for carrying away the finished pieces. The hub carrying the feedwheel can be adjusted vertically for various thicknesses of work. The lower platen remains in a fixed position and the lower wheel is adjusted level with it. Manufacturer: Charles H. Besly and Co., Chicago.

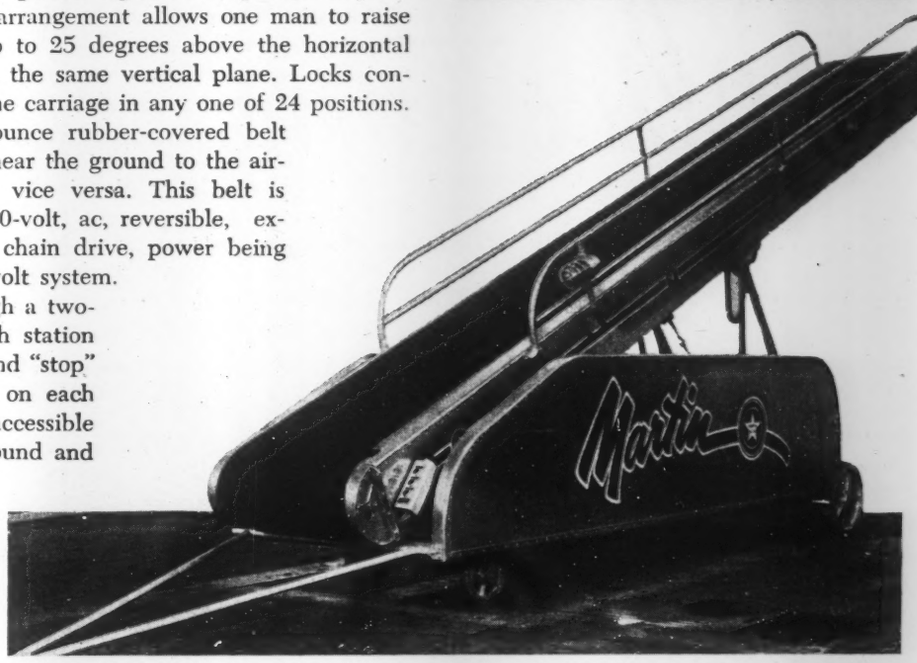
## Cargo Loader for Aircraft

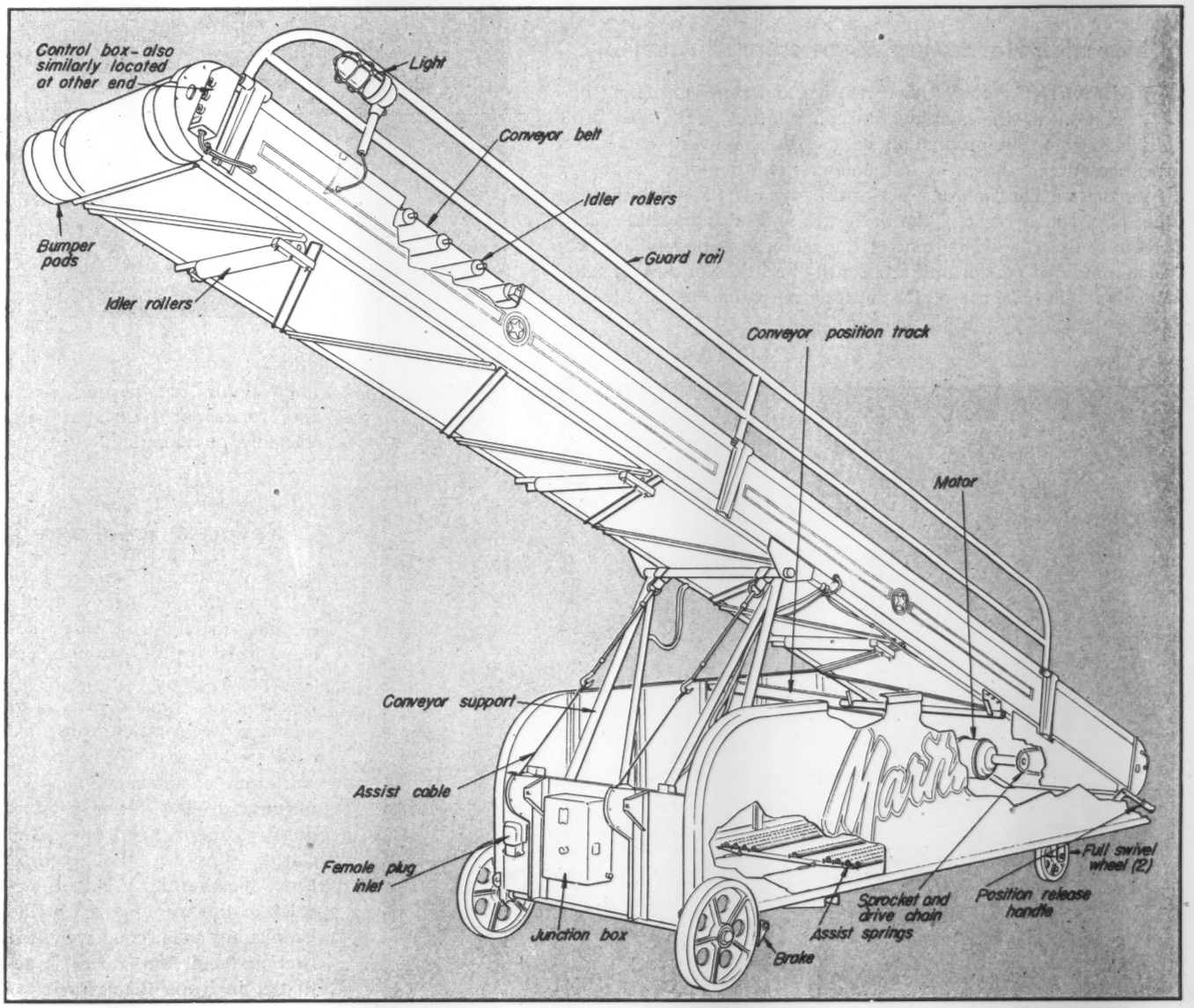
ADJUSTABLE to sills of aircraft cargo-hatches located between 43 and 120 inches above ground level, this mechanized cargo loader has a riveted, aluminum-alloy chassis mounted on two sixteen-inch wheels and two full-swivel, ten-inch casters. Both the wheels and the casters are fitted with detachable solid rubber tires, roller bearings and pressure-lubrication fittings. Two foot-operated truck locks mounted outboard of the casters, and brakes on the two wheels serve to hold the loader stationary. A tow bar facilitates movement of the loader to and from planes.

A spring-loaded carriage is mounted in channel-shaped

tracks on the chassis in a manner permitting its lower portion to pivot and slide simultaneously. This arrangement allows one man to raise the carriage to any position up to 25 degrees above the horizontal while its upper end remains in the same vertical plane. Locks controlled by the operator secure the carriage in any one of 24 positions. A 24-inch wide, four-ply, 28-ounce rubber-covered belt carries the cargo from a point near the ground to the airplane cargo compartment and vice versa. This belt is driven by a 1½-horsepower, 110-volt, ac, reversible, explosion-proof motor through a chain drive, power being obtained from the airport 110-volt system.

The motor is operated through a two-station pushbutton control, each station consisting of an "up", "down" and "stop" control. One station is located on each end of the carriage so as to be accessible to both the operator on the ground and the man in the cargo compartment of the airplane. A light is installed near each station. Manufacturer: The Glenn L. Martin Co., Baltimore 3, Md.



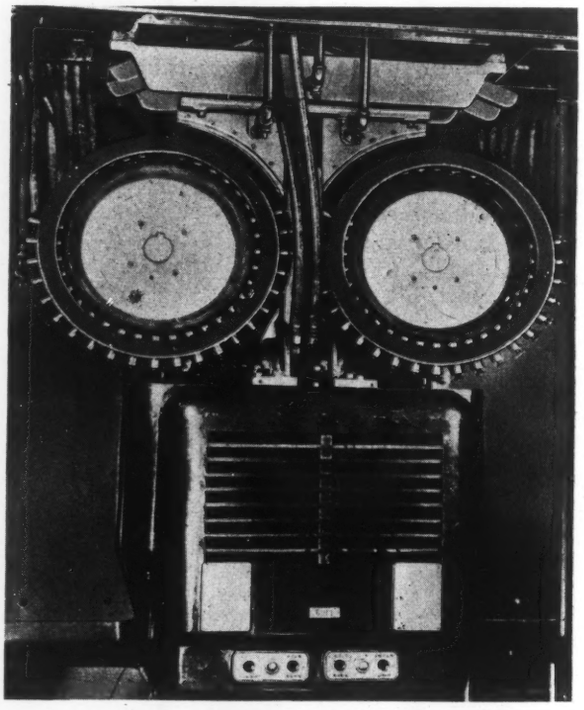



# Applications

## of engineering parts, materials and processes

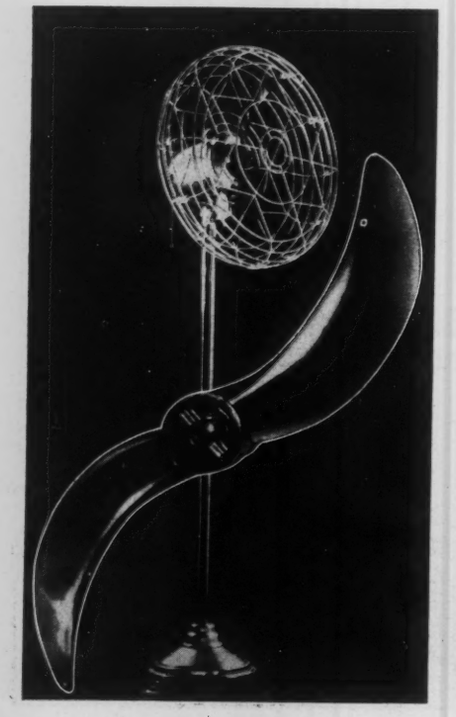
### Precise Molding Yields Perfect Balance

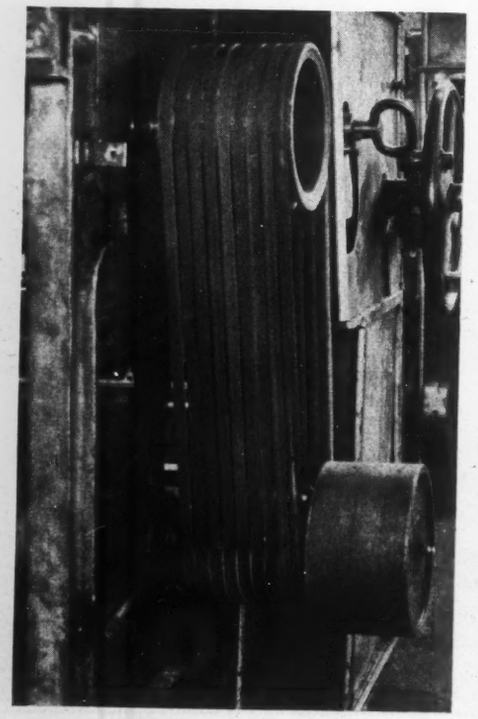
HARDENING of tappets to 55 rockwell C at the rate of 70,000 per day is accomplished in the Tocco induction-hardening machine, right. The tappet, of cast iron with a steel insert brazed to its end, is inserted in a hole in the rim of a rotating wheel. Passing through the high-frequency field produced by a Westinghouse 3000-cycle generator, seat and shoulder of tappet are heated to 1500 F and quenched in three seconds. Heat is so localized that the other end of tappet remains cool. Braze is entirely unaffected by the operation.



### Induction Hardening Follows Braze Assembly

BALANCING, always an expensive and time-consuming operation in the manufacture of rotating parts, has been eliminated in the production of the Fresh'nd-Aire company's two-bladed fan shown at left below. The one-piece propeller is molded of Durez, using preforms. By carefully determining the shape and weight of the preforms, and arranging them in a precisely determined pattern in the mold, it is possible to produce a molded part of uniform density and thus of perfect static and dynamic balance. Only finishing operation on the blade is removal of the parting flash. Fan rotates at 1600 rpm with virtually no vibration.





### Reduces Breakage

SLOW starting, essential to operation of heavy textile spinning machines, is easily accomplished by the Bethlehem slip-ring starter, left. To avoid breaking of threads, period of machine acceleration must exceed six seconds. The slip-ring starter clutch allows the general-purpose driving motor to start quickly under no load. The starter slips for the required time, allowing the V-belts to accelerate the machine gradually. Employing an internal weighted friction band, the starter is actuated by centrifugal force.

# Helical Spring Design Tables

By H. F. Ross
*Research Division*
*United Shoe Machinery Corp.*
*Beverly, Mass.*

DESIGN of helical compression and tension springs from round wire of any given material may be reduced to a few simple steps by the use of the tables on the following pages. The tables include all standard steel wire gages between 0.025 and 0.394-inch (Washburn & Moen), music wire gages between 0.010 and 0.118-inch and most of the even fractional dimensions. For any given outside diameter between ⅛-inch and 4½ inches, all of these gage sizes may be found which fall within the index extremes ($D/d$) of 3 and 20. Odd wire sizes or nonferrous materials may also be handled with little additional work.

In each space on the tables are two numbers. The top number is the load in pounds which a spring of any material will sustain at 100,000 psi stress, corrected to include Wahl's factor. This value may or may not be the safe stress for the conditions imposed upon the spring in service or for the material selected, but regardless of what stress is selected, the load will change in direct proportion to the change in stress. Since any stress selected is immediately apparent as a percentage of 100,000, and the load will also change by the same percentage, this makes a convenient base on which to start. For example, if the safe stress were determined to be 150,000 psi, the load-carrying capacity of the spring, as listed, would be multiplied by 1.5. These loads are independent of the number of coils in the spring or the material used. Safe stresses for both static and fatigue conditions will be discussed later.

The lower number appearing in the space is the spring scale per single coil of wire. To get the scale or rate of any steel spring, merely divide by the number of active coils. For nonferrous materials, the result obtained for steel must be multiplied by a factor dependent upon the relative value of the shearing modulus of elasticity to that of steel. This factor, $A$, is listed for common spring materials in TABLE I.

TABLE I

**Ratio of Torsional Modulus Of Elasticity to That of Steel**

| Material | Ratio A |
|---|---|
| 18-8 Stainless Steel | 0.8696 |
| Brass | 0.4783 |
| Phosphor Bronze | 0.5435 |
| Monel or K-Monel | 0.8261 |

Deflection per single coil of wire is equal to the load divided by the scale per single coil, that is, the top number divided by the lower number in each space of the tables. This result when multiplied by the number of active coils represents the total deflection of the spring at 100,000 psi. Here again, a percentage change from the basic stress of 100,000 psi will result in an equal percentage change in deflection. For materials other than steel, the deflection obtained by use of the tables must be divided by the correction factor, $A$, TABLE I.

TABLE II

**Recommended Maximum Torsional Design Stresses for Helical Compression Springs Under Average Service Conditions***

| Wire Diam. (inches) | Plain Carbon Steels: Music Wire (psi) | Tempered Steel (psi) | Hard-Drawn Steel (psi) |
|---|---|---|---|
| 0.020 to 0.030 | 100,000 | 100,000 | 90,000 |
| 0.031 to 0.092 | 90,000 | 100,000 | 80,000 |
| 0.093 to 0.176 | 90,000 | 90,000 | 80,000 |
| 0.177 to 0.282 | ..... | 90,000 | 70,000 |
| 0.283 to 0.436 | ..... | 85,000 | |
| 0.437 to 0.624 | ..... | 80,000 | Cold wound for OD>3 inches |
| 0.437 to 0.624 | ..... | 90,000 | Hot wound for OD<3 inches |
| 0.625 to 0.874 | ..... | 90,000 | Hot wound |
| 0.875 to 1.500 | ..... | 80,000 | Hot wound |

* Data from *Manual of Spring Engineering*, American Steel & Wire Co.

From the basic figures listed in the tables any spring of reasonable proportions up to 4½ inches OD may be designed with nothing more than a simple multiplication or division required to extrapolate to the desired stresses.

Another characteristic of this type of table is the comparative value offered by the various combinations of outside diameter and wire size which will give similar characteristics. Since all values listed are for standard wire sizes, the data to obtain the same or varying characteristics are readily available by inspection, making wire substitution particularly easy.

Table values are derived from the basic spring equations reduced to simplest form. The load (top number in the table) is derived from the equation (see Nomenclature):

$$P = \pi s d^3/8 DK$$

Since $s = 100{,}000$ and $D/d = c$, this reduces to

Based on a paper presented at a recent meeting of the Machine Design division of A.S.M.E.

## OUTSIDE DIAMETER OF COIL—INCHES

| Wire Dia. d. | 1/8 | 9/64 | 5/32 | 11/64 | 3/16 | 13/64 | 7/32 | 15/64 | 1/4 | 17/64 | 9/32 | 19/64 | 5/16 | 21/64 | 11/32 | 23/64 | 3/8 | 25/64 | 13/32 | 27/64 | 7/16 | 29/64 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| .010 | .305<br>9.47 | ← Load in lbs. at 100,000 psi — Wahl's Factor "K" included<br>← Spring scale per single coil | | | | | | | | | | | | | | | | | | | | |
| .011 | .401<br>14.1 | .360<br>9.63 | .325<br>6.90 | | | | | | | | | | | | | | | | | | | |
| .012 | .522<br>20.7 | .464<br>13.8 | .421<br>10.0 | .383<br>7.32 | .350<br>5.43 | | | | | | | | | | | | | | | | | |
| .013 | .659<br>29.3 | .592<br>19.6 | .534<br>14.0 | .486<br>10.3 | .447<br>7.61 | .414<br>6.01 | .386<br>4.72 | | | | | | | | | | | | | | | |
| .014 | .823<br>40.3 | .732<br>26.9 | .669<br>19.4 | .603<br>14.0 | .560<br>10.5 | .519<br>8.19 | .480<br>6.45 | .450<br>5.20 | .422<br>4.18 | | | | | | | | | | | | | |
| .016 | 1.21<br>72.9 | 1.08<br>48.2 | .983<br>34.4 | .897<br>24.8 | .824<br>18.4 | .768<br>14.4 | .714<br>11.3 | .673<br>9.13 | .626<br>7.37 | .592<br>6.06 | .561<br>5.05 | | | | | | | | | | | |
| .018 | 1.71<br>124 | 1.53<br>81.0 | 1.40<br>57.4 | 1.27<br>41.2 | 1.17<br>30.7 | 1.08<br>23.7 | 1.01<br>18.6 | .947<br>15.0 | .889<br>12.1 | .839<br>9.87 | .793<br>8.30 | .754<br>6.96 | | | | | | | | | | |
| .020 | 2.32<br>200 | 2.08<br>130 | 1.89<br>91.3 | 1.74<br>65.4 | 1.60<br>48.6 | 1.48<br>37.5 | 1.39<br>29.3 | 1.30<br>23.5 | 1.22<br>18.9 | 1.14<br>15.4 | 1.08<br>12.8 | 1.03<br>10.8 | .972<br>9.06 | .936<br>7.87 | | | | | | | | |
| .022 | 3.03<br>306 | 2.75<br>199 | 2.50<br>140 | 2.29<br>100 | 2.12<br>73.9 | 1.96<br>56.8 | 1.83<br>44.0 | 1.72<br>35.5 | 1.60<br>28.2 | 1.52<br>23.2 | 1.44<br>19.3 | 1.37<br>16.2 | 1.30<br>13.7 | 1.24<br>11.7 | 1.18<br>10.1 | | | | | | | |
| .024 | 3.90<br>464 | 3.51<br>297 | 3.22<br>208 | 2.96<br>147 | 2.72<br>108 | 2.53<br>83.2 | 2.36<br>64.3 | 2.23<br>51.5 | 2.09<br>41.4 | 1.97<br>33.6 | 1.87<br>28.2 | 1.77<br>23.4 | 1.68<br>19.9 | 1.61<br>16.9 | 1.53<br>14.6 | 1.47<br>12.6 | 1.41<br>11.1 | 1.36<br>9.67 | 1.31<br>8.62 | 1.26<br>7.54 | 1.21<br>6.67 | 1.17<br>6.02 |
| .025 | 4.36<br>566 | 3.95<br>359 | 3.63<br>250 | 3.32<br>177 | 3.06<br>130 | 2.85<br>99.3 | 2.66<br>77.1 | 2.51<br>61.5 | 2.35<br>49.2 | 2.22<br>40.3 | 2.11<br>33.7 | 1.99<br>27.7 | 1.91<br>23.7 | 1.81<br>20.2 | 1.74<br>17.6 | 1.65<br>15.0 | 1.59<br>13.1 | 1.53<br>11.5 | 1.48<br>10.2 | 1.42<br>8.98 | 1.38<br>8.01 | 1.33<br>7.19 |
| .026 | 4.88<br>678 | 4.42<br>433 | 4.06<br>299 | 3.72<br>210 | 3.44<br>155 | 3.20<br>119 | 2.98<br>91.1 | 2.81<br>72.8 | 2.63<br>58.4 | 2.48<br>47.5 | 2.35<br>39.6 | 2.24<br>33.2 | 2.14<br>28.0 | 2.04<br>23.9 | 1.94<br>20.5 | 1.87<br>17.8 | 1.79<br>15.5 | 1.73<br>13.6 | 1.65<br>12.0 | 1.60<br>10.6 | 1.54<br>9.43 | 1.50<br>8.47 |
| .028 | 5.98<br>965 | 5.45<br>612 | 4.99<br>419 | 4.61<br>297 | 4.25<br>216 | 3.98<br>165 | 3.70<br>127 | 3.49<br>101 | 3.29<br>80.6 | 3.10<br>65.7 | 2.94<br>54.5 | 2.79<br>45.4 | 2.65<br>38.0 | 2.55<br>32.9 | 2.41<br>28.1 | 2.33<br>24.4 | 2.24<br>21.1 | 2.14<br>18.4 | 2.07<br>16.4 | 1.99<br>14.4 | 1.92<br>12.9 | 1.86<br>11.5 |
| .029 | 6.61<br>1160 | 6.03<br>727 | 5.55<br>496 | 5.08<br>348 | 4.71<br>253 | 4.41<br>193 | 4.10<br>149 | 3.86<br>118 | 3.64<br>94.1 | 3.43<br>76.6 | 3.25<br>63.7 | 3.11<br>53.0 | 2.94<br>44.6 | 2.81<br>38.1 | 2.71<br>32.9 | 2.59<br>28.2 | 2.50<br>24.6 | 2.38<br>21.4 | 2.29<br>18.9 | 2.21<br>16.7 | 2.13<br>14.9 | 2.06<br>13.4 |
| .031 | 7.94<br>1588 | 7.24<br>992 | 6.69<br>683 | 6.15<br>473 | 5.74<br>344 | 5.36<br>260 | 4.99<br>200 | 4.69<br>159 | 4.42<br>126 | 4.15<br>102 | 3.97<br>85.2 | 3.76<br>70.7 | 3.58<br>59.2 | 3.43<br>50.7 | 3.28<br>43.5 | 3.15<br>37.5 | 3.01<br>32.7 | 2.91<br>28.6 | 2.79<br>25.1 | 2.70<br>22.3 | 2.60<br>19.8 | 2.52<br>17.7 |
| .032 | | 7.87<br>1157 | 7.30<br>793 | 6.76<br>545 | 6.25<br>398 | 5.84<br>301 | 5.47<br>231 | 5.14<br>184 | 4.84<br>146 | 4.59<br>118 | 4.35<br>97.8 | 4.12<br>81.1 | 3.95<br>68.0 | 3.75<br>58.1 | 3.60<br>49.9 | 3.46<br>43.3 | 3.33<br>37.5 | 3.18<br>32.7 | 3.07<br>28.7 | 2.95<br>25.4 | 2.85<br>22.4 | 2.75<br>20.1 |
| .033 | | 8.61<br>1367 | 7.97<br>916 | 7.37<br>635 | 6.85<br>460 | 6.39<br>345 | 5.97<br>265 | 5.62<br>210 | 5.29<br>166 | 5.01<br>135 | 4.74<br>112 | 4.53<br>92.4 | 4.31<br>77.5 | 4.13<br>66.5 | 3.96<br>56.9 | 3.77<br>49.3 | 3.61<br>42.4 | 3.51<br>37.5 | 3.35<br>32.8 | 3.24<br>28.9 | 3.11<br>25.6 | 3.04<br>23.2 |
| .035 | | 10.1<br>1804 | 9.34<br>1213 | 8.67<br>834 | 8.10<br>604 | 7.54<br>457 | 7.10<br>346 | 6.66<br>274 | 6.32<br>217 | 5.93<br>175 | 5.66<br>145 | 5.36<br>120 | 5.14<br>101 | 4.92<br>85.9 | 4.72<br>74.0 | 4.48<br>63.4 | 4.32<br>55.0 | 4.14<br>47.6 | 4.02<br>42.2 | 3.84<br>37.0 | 3.73<br>33.0 | 3.61<br>29.8 |
| .037 | | | 10.9<br>1580 | 10.1<br>1098 | 9.42<br>785 | 8.88<br>588 | 8.28<br>448 | 7.84<br>353 | 7.41<br>280 | 7.01<br>225 | 6.64<br>186 | 6.33<br>154 | 6.01<br>128 | 5.75<br>110 | 5.51<br>94.2 | 5.29<br>80.9 | 5.07<br>69.6 | 4.89<br>60.7 | 4.73<br>53.9 | 4.54<br>47.3 | 4.41<br>42.2 | 4.25<br>37.7 |
| .039 | | | 12.6<br>2066 | 11.7<br>1410 | 10.9<br>1009 | 10.3<br>752 | 9.66<br>572 | 9.13<br>448 | 8.63<br>354 | 8.15<br>284 | 7.76<br>234 | 7.34<br>193 | 7.03<br>162 | 6.72<br>138 | 6.45<br>118 | 6.17<br>101 | 5.93<br>87.9 | 5.71<br>76.2 | 5.52<br>67.3 | 5.29<br>59.2 | 5.14<br>52.8 | 4.99<br>47.0 |
| .041 | | | | 13.4<br>1811 | 12.5<br>1276 | 11.9<br>960 | 11.1<br>716 | 10.5<br>561 | 9.96<br>445 | 9.40<br>356 | 8.96<br>294 | 8.54<br>243 | 8.10<br>203 | 7.80<br>172 | 7.47<br>147 | 7.15<br>126 | 6.85<br>109 | 6.61<br>94.7 | 6.39<br>83.5 | 6.18<br>73.5 | 5.92<br>64.7 | 5.80<br>58.8 |
| .043 | | | | 15.3<br>2284 | 14.4<br>1618 | 13.5<br>1205 | 12.7<br>901 | 12.0<br>706 | 11.4<br>559 | 10.8<br>443 | 10.3<br>368 | 9.76<br>300 | 9.33<br>249 | 8.91<br>212 | 8.60<br>183 | 8.24<br>156 | 7.91<br>134 | 7.61<br>117 | 7.36<br>103 | 7.11<br>90.5 | 6.82<br>80.0 | 6.63<br>71.4 |
| .045 | | | | | 16.3<br>2012 | 15.3<br>1485 | 14.5<br>1115 | 13.7<br>873 | 12.9<br>679 | 12.3<br>549 | 11.8<br>452 | 11.2<br>368 | 10.7<br>306 | 10.2<br>260 | 9.77<br>223 | 9.42<br>190 | 9.05<br>165 | 8.70<br>142 | 8.41<br>126 | 8.12<br>110 | 7.79<br>97.01 | 7.56<br>86.7 |
| .047 | | | | | 18.3<br>2507 | 17.3<br>1860 | 16.4<br>1378 | 15.5<br>1069 | 14.7<br>840 | 13.9<br>671 | 13.3<br>547 | 12.6<br>448 | 12.1<br>373 | 11.6<br>316 | 11.1<br>270 | 10.6<br>230 | 10.3<br>199 | 9.88<br>172 | 9.54<br>151 | 9.22<br>133 | 8.90<br>117 | 8.59<br>105 |
| .049 | | | | | | 19.4<br>2282 | 18.4<br>1688 | 17.3<br>1301 | 16.4<br>1019 | 15.7<br>813 | 15.0<br>667 | 14.3<br>544 | 13.7<br>452 | 13.1<br>383 | 12.6<br>328 | 12.0<br>278 | 11.6<br>240 | 11.2<br>208 | 10.8<br>182 | 10.4<br>160 | 10.1<br>141 | 9.70<br>126 |
| .051 | | | | | | | 20.4<br>2061 | 19.5<br>1585 | 18.5<br>1233 | 17.6<br>983 | 16.8<br>800 | 15.9<br>652 | 15.3<br>543 | 14.7<br>458 | 14.2<br>389 | 13.5<br>332 | 13.0<br>288 | 12.6<br>248 | 12.1<br>217 | 11.7<br>191 | 11.3<br>168 | 10.9<br>150 |
| .054 | | | | | | | 23.9<br>2716 | 22.8<br>2092 | 21.6<br>1624 | 20.5<br>1281 | 19.8<br>1048 | 18.9<br>855 | 18.0<br>706 | 17.4<br>596 | 16.6<br>509 | 16.0<br>431 | 15.4<br>370 | 14.8<br>320 | 14.3<br>281 | 13.8<br>246 | 13.3<br>216 | 12.9<br>192 |
| .055 | | | | | | | | 24.1<br>2295 | 22.8<br>1767 | 21.7<br>1400 | 20.8<br>1143 | 19.9<br>934 | 18.9<br>768 | 18.3<br>649 | 17.6<br>553 | 16.8<br>468 | 16.2<br>401 | 15.6<br>347 | 15.1<br>304 | 14.6<br>266 | 14.1<br>234 | 13.7<br>209 |
| .059 | | | | | | | | | 27.6<br>2509 | 26.3<br>1963 | 25.3<br>1591 | 24.2<br>1294 | 23.2<br>1059 | 22.2<br>895 | 21.4<br>770 | 20.7<br>647 | 19.9<br>554 | 19.1<br>475 | 18.5<br>418 | 17.8<br>365 | 17.3<br>322 | 16.8<br>285 |
| .063 | | | | | | | | | | 31.7<br>2709 | 30.3<br>2196 | 29.0<br>1779 | 27.9<br>1461 | 26.8<br>1213 | 25.8<br>1032 | 24.8<br>873 | 23.8<br>721 | 23.0<br>641 | 22.4<br>562 | 21.5<br>489 | 20.9<br>429 | 20.3<br>382 |
| .067 | | | | | | | | | | | 35.9<br>2967 | 34.5<br>2379 | 33.1<br>1947 | 31.9<br>1628 | 30.8<br>1381 | 29.5<br>1161 | 28.6<br>986 | 27.6<br>849 | 26.8<br>744 | 25.8<br>648 | 25.1<br>569 | 24.3<br>504 |
| .071 | | | | | | | | | | | | 40.5<br>3189 | 38.7<br>2563 | 37.5<br>2155 | 36.2<br>1783 | 34.9<br>1531 | 33.4<br>1295 | 32.5<br>1113 | 31.5<br>972 | 30.6<br>845 | 29.4<br>741 | 28.8<br>656 |
| .072 | | | | | | | | | | | | 42.0<br>3415 | 40.3<br>2760 | 38.9<br>2302 | 37.6<br>1938 | 36.2<br>1631 | 35.1<br>1382 | 33.8<br>1190 | 32.8<br>1035 | 31.8<br>903 | 30.8<br>786 | 29.9<br>700 |
| .075 | | | | | | | | | | | | | 45.3<br>3381 | 43.7<br>2819 | 42.1<br>2379 | 40.8<br>1981 | 39.2<br>1690 | 38.0<br>1445 | 36.9<br>1259 | 35.6<br>1085 | 34.6<br>953 | 33.5<br>844 |
| .077 | | | | | | | | | | | | | | 46.7<br>3199 | 45.3<br>2696 | 43.9<br>2263 | 42.4<br>1910 | 40.8<br>1632 | 39.5<br>1421 | 38.5<br>1230 | 37.1<br>1075 | 36.2<br>953 |
| .080 | | | | | | | | | | | | | | 52.0<br>3852 | 50.3<br>3245 | 48.7<br>2706 | 47.1<br>2300 | 45.5<br>1953 | 44.1<br>1705 | 42.9<br>1469 | 41.3<br>1285 | 40.3<br>1138 |
| .085 | | | | | | | | | | | | | | | 59.3<br>4328 | 57.6<br>3646 | 55.5<br>3083 | 54.0<br>2621 | 52.2<br>2270 | 50.9<br>1965 | 49.2<br>1708 | 47.9<br>1506 |
| .090 | | | | | | | | | | | | | | | | | 65.2<br>4075 | 63.1<br>3467 | 61.3<br>2990 | 59.5<br>2576 | 57.9<br>2236 | 56.4<br>1979 |
| .092 | | | | | | | | | | | | | | | | | 69.3<br>4530 | 66.9<br>3845 | 64.9<br>3330 | 63.0<br>2864 | 61.0<br>2490 | 59.8<br>2199 |
| .095 | | | | | | | | | | | | | | | | | | 73.3<br>4497 | 71.4<br>3902 | 69.2<br>3359 | 67.3<br>2901 | 65.3<br>2551 |
| .100 | | | | | | | | | | | | | | | | | | | 81.8<br>5018 | 79.8<br>4314 | 77.5<br>3726 | 75.7<br>3263 |
| .105 | | | | | | | | | | | | | | | | | | | | 90.8<br>5470 | 88.6<br>4720 | 86.1<br>4159 |
| .106 | | | | | | | | | | | | | | | | | | | | | 91.0<br>4973 | 88.8<br>4353 |
| .109 | | | | | | | | | | | | | | | | | | | | | | 95.3<br>4964 |

$$P = 39300\ d^2/cK$$

The spring scale per coil (bottom number in each square) is derived in the following manner:

$$k/\text{coil} = P/f$$

$$f = 8PD^3/d^4G$$

$$k/\text{coil} = d^4G/8D^3 = 1{,}437{,}500\ d/c^3$$

where $G = 11.5 \times 10^6$. For nonferrous materials this becomes

$$1{,}437{,}500\ dA/c^3$$

Since the load value in each space of the table is independent of material used, this correction is all that is necessary to proceed with the design of the spring.

Because of the close increments of the table, either odd wire sizes or coil diameters may be interpolated linearly with negligible error. Similarly, when the outside diameter or combination of both outside diameter and wire diameter are odd sizes, the interpolated values will closely approximate the calculated values.

### Nomenclature

- $A$ = Ratio of Torsional Modulus of Elasticity to that of Steel
- $c$ = Spring Index
- $d$ = Wire Diameter, inches
- $D$ = Mean Diameter, inches
- $f$ = Deflection Per Coil, inches
- $G$ = Shearing modulus of elasticity, psi
- $k$ = Spring constant, lb per in.
- $K$ = Stress Multiplication (Wahl's) Factor
- $L$ = Length, inches
- $N$ = Number of Active Coils
- $P$ = Load, pounds
- $s$ = Stress, psi

### Selection of Working Stresses

WORKING STRESSES: Standardization of stresses which will provide satisfactory life for a majority of spring uses is desirable from a viewpoint of simplicity. Suitable values are given in TABLE II, which applies to average service conditions—slow or static loading of a spring at normal temperature in a noncorrosive atmosphere. Stresses either higher or lower may be used at the discretion of the designer for the particular case.

FATIGUE: The usual method of designing springs to withstand continuous stress repetition is to base the calculations upon stress range. The endurance limit of the wire, or ability to withstand complete reversal of stress, is dependent upon wire diameter and material. Some suggested stress ranges for various wire sizes and materials are listed in TABLE III.

These values represent the approximate torsional endurance limit of the wire, and should theoretically give unlimited life. However, this is for ideal conditions and contains no factor of safety. Such things

| Wire Dia. d. | OUTSIDE DIAMETER OF COIL—IN. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 15/32 | 31/64 | 1/2 | 17/32 | 9/16 | 19/32 | 5/8 | 21/32 | 11/16 | 23/32 | 3/4 |
| .024 | 1.14 ← Load in lbs. at 100,000 psi — Wahl's Factor "K" included<br>5.42 ← Spring scale per single coil | | | | | | | | | | |
| .025 | 1.28<br>6.40 | 1.24<br>5.81 | | | | | | | | | |
| .026 | 1.44<br>7.55 | 1.40<br>6.87 | 1.35<br>6.18 | 1.28<br>5.11 | | | | | | | |
| .028 | 1.79<br>10.3 | 1.73<br>9.29 | 1.69<br>8.37 | 1.58<br>6.91 | 1.51<br>5.79 | | | | | | |
| .029 | 2.00<br>12.00 | 1.93<br>10.8 | 1.87<br>9.75 | 1.77<br>8.07 | 1.66<br>6.66 | 1.58<br>5.60 | | | | | |
| .031 | 2.44<br>15.9 | 2.35<br>14.3 | 2.29<br>12.9 | 2.15<br>10.7 | 2.03<br>8.77 | 1.92<br>7.40 | 1.84<br>6.31 | | | | |
| .032 | 2.67<br>17.9 | 2.59<br>16.4 | 2.51<br>14.8 | 2.37<br>12.1 | 2.24<br>10.0 | 2.12<br>8.47 | 2.03<br>7.27 | 1.93<br>6.20 | | | |
| .033 | 2.92<br>20.5 | 2.84<br>18.5 | 2.74<br>16.7 | 2.60<br>13.8 | 2.45<br>11.4 | 2.33<br>9.67 | 2.21<br>8.26 | 2.12<br>7.07 | 2.02<br>6.11 | | |
| .035 | 3.50<br>26.3 | 3.39<br>24.0 | 3.29<br>21.4 | 3.08<br>17.7 | 2.93<br>14.7 | 2.62<br>11.7 | 2.64<br>10.4 | 2.52<br>9.04 | 2.41<br>7.72 | 2.31<br>6.77 | |
| .037 | 4.11<br>32.8 | 3.97<br>30.1 | 3.88<br>27.3 | 3.62<br>22.2 | 3.44<br>18.5 | 3.27<br>15.5 | 3.10<br>13.3 | 2.98<br>11.4 | 2.83<br>9.77 | 2.73<br>8.52 | 2.61<br>7.43 |
| .039 | 4.80<br>41.1 | 4.68<br>37.8 | 4.52<br>34.1 | 4.27<br>28.0 | 4.06<br>23.3 | 3.83<br>19.6 | 3.66<br>16.6 | 3.47<br>14.2 | 3.33<br>12.2 | 3.18<br>10.6 | 3.04<br>9.30 |
| .041 | 5.60<br>51.8 | 5.41<br>46.8 | 5.26<br>41.9 | 4.94<br>34.6 | 4.69<br>28.8 | 4.45<br>24.0 | 4.23<br>20.5 | 4.04<br>17.5 | 3.84<br>14.9 | 3.71<br>13.1 | 3.54<br>11.4 |
| .043 | 6.43<br>63.7 | 6.19<br>56.8 | 6.07<br>51.6 | 5.69<br>42.6 | 5.36<br>34.9 | 5.11<br>29.4 | 4.89<br>25.0 | 4.62<br>21.2 | 4.44<br>18.3 | 4.25<br>16.0 | 4.10<br>14.0 |
| .045 | 7.35<br>77.5 | 7.09<br>69.6 | 6.91<br>62.5 | 6.52<br>51.5 | 6.18<br>42.5 | 5.82<br>35.6 | 5.56<br>30.3 | 5.32<br>25.8 | 5.06<br>22.2 | 4.87<br>19.2 | 4.65<br>16.8 |
| .047 | 8.33<br>93.3 | 8.12<br>84.1 | 7.83<br>75.6 | 7.39<br>61.9 | 6.99<br>51.0 | 6.68<br>43.2 | 6.35<br>36.2 | 6.02<br>30.9 | 5.81<br>26.6 | 5.52<br>23.1 | 5.31<br>20.1 |
| .049 | 9.41<br>112 | 9.16<br>101 | 8.84<br>90.8 | 8.41<br>73.8 | 7.95<br>60.7 | 7.52<br>51.5 | 7.14<br>43.2 | 6.86<br>37.0 | 6.54<br>32.0 | 6.26<br>27.4 | 6.00<br>24.1 |
| .051 | 10.6<br>134 | 10.3<br>120 | 10.0<br>107 | 9.45<br>88.3 | 8.97<br>73.0 | 8.53<br>61.4 | 8.01<br>51.1 | 7.67<br>43.6 | 7.37<br>37.5 | 7.18<br>33.3 | 6.78<br>28.6 |
| .054 | 12.5<br>171 | 12.2<br>154 | 11.8<br>138 | 11.2<br>113 | 10.6<br>93.1 | 10.1<br>78.4 | 9.57<br>65.1 | 9.14<br>56.7 | 8.75<br>48.3 | 8.39<br>41.8 | 8.00<br>36.2 |
| .055 | 13.3<br>187 | 12.8<br>167 | 12.4<br>149 | 11.7<br>122 | 11.2<br>101 | 10.65<br>83.8 | 10.0<br>70.4 | 9.62<br>60.5 | 9.23<br>51.9 | 8.77<br>45.0 | 8.50<br>39.5 |
| .059 | 16.3<br>253 | 15.7<br>227 | 15.3<br>204 | 14.5<br>166 | 13.7<br>137 | 13.0<br>113 | 12.4<br>96.3 | 11.9<br>82.2 | 11.3<br>69.4 | 10.8<br>60.4 | 10.4<br>52.7 |
| .063 | 19.7<br>338 | 19.1<br>303 | 18.6<br>272 | 17.5<br>221 | 16.6<br>181 | 15.8<br>151 | 15.1<br>128 | 14.4<br>109 | 13.8<br>92.6 | 13.2<br>80.9 | 12.7<br>70.0 |
| .067 | 23.5<br>446 | 22.9<br>401 | 22.2<br>358 | 21.0<br>290 | 19.9<br>239 | 18.8<br>198 | 17.9<br>166 | 17.3<br>142 | 16.5<br>121 | 15.8<br>105 | 15.2<br>90.7 |
| .071 | 27.8<br>580 | 27.0<br>518 | 26.1<br>463 | 24.8<br>375 | 23.6<br>307 | 22.4<br>256 | 21.3<br>215 | 20.3<br>183 | 19.5<br>156 | 18.6<br>139 | 18.0<br>117 |
| .072 | 28.9<br>618 | 28.0<br>552 | 27.4<br>495 | 26.0<br>460 | 24.5<br>328 | 23.4<br>273 | 22.3<br>229 | 21.3<br>193 | 20.3<br>165 | 19.5<br>142 | 18.8<br>124 |
| .075 | 32.6<br>748 | 31.7<br>666 | 30.7<br>592 | 29.1<br>480 | 27.6<br>390 | 26.4<br>325.5 | 25.1<br>274 | 24.0<br>232 | 22.9<br>197 | 22.0<br>170 | 21.2<br>148 |
| .077 | 35.2<br>840 | 34.1<br>748 | 33.2<br>669 | 31.3<br>541 | 29.8<br>442 | 28.5<br>368 | 27.0<br>305 | 25.8<br>260 | 24.9<br>221 | 23.9<br>192 | 22.8<br>166 |
| .080 | 39.2<br>1000 | 38.0<br>894 | 36.9<br>795 | 34.5<br>640 | 33.4<br>525 | 31.8<br>432 | 30.2<br>364 | 28.9<br>309 | 27.8<br>262 | 26.7<br>227 | 25.7<br>196 |
| .085 | 46.5<br>1325 | 45.2<br>1183 | 44.1<br>1053 | 41.9<br>845 | 39.8<br>689 | 37.9<br>569 | 36.1<br>478 | 34.6<br>403 | 33.1<br>343 | 31.7<br>294 | 30.5<br>255 |
| .090 | 54.8<br>1734 | 53.4<br>1539 | 51.7<br>1368 | 49.2<br>1101 | 46.9<br>890 | 44.8<br>738 | 42.9<br>617 | 40.8<br>520 | 39.0<br>442 | 37.6<br>379 | 36.2<br>329 |
| .092 | 58.4<br>1920 | 56.6<br>1710 | 55.1<br>1515 | 52.3<br>1220 | 50.0<br>986 | 47.7<br>816 | 45.6<br>683 | 43.4<br>574 | 41.7<br>488 | 40.0<br>418 | 38.4<br>363 |
| .095 | 63.8<br>2231 | 61.9<br>1997 | 60.3<br>1763 | 57.7<br>1414 | 54.5<br>1140 | 52.4<br>944 | 50.0<br>786 | 47.6<br>662 | 45.8<br>562 | 43.9<br>482 | 42.2<br>417 |
| .100 | 73.5<br>2860 | 71.6<br>2539 | 69.7<br>2248 | 66.6<br>1800 | 63.3<br>1449 | 60.7<br>1193 | 58.0<br>993 | 55.7<br>838 | 53.0<br>707 | 51.2<br>607 | 49.2<br>525 |
| .105 | 84.5<br>3640 | 82.2<br>3211 | 79.8<br>2830 | 76.2<br>2250 | 72.5<br>1820 | 69.4<br>1495 | 66.7<br>1246 | 64.0<br>1047 | 60.8<br>880 | 58.8<br>756 | 56.9<br>653 |
| .106 | 86.7<br>3803 | 84.1<br>3351 | 81.9<br>2967 | 78.1<br>2367 | 74.8<br>1903 | 71.6<br>1563 | 68.3<br>1298 | 65.4<br>1090 | 62.8<br>921 | 60.6<br>789 | 58.1<br>679 |
| .109 | 93.7<br>4358 | 91.1<br>3844 | 89.1<br>3388 | 85.0<br>2681 | 81.1<br>2163 | 77.2<br>1775 | 74.2<br>1481 | 71.0<br>1241 | 68.2<br>1048 | 65.7<br>894 | 63.0<br>771 |
| .112 | 100<br>4950 | 98.3<br>4408 | 95.6<br>3886 | 91.5<br>3081 | 87.4<br>2462 | 83.7<br>2027 | 79.7<br>1678 | 76.8<br>1404 | 73.8<br>1186 | 71.1<br>1013 | 68.1<br>871 |
| .118 | | 113<br>5678 | 110<br>4977 | 106<br>3970 | 101<br>3176 | 97.0<br>2594 | 92.9<br>2136 | 88.9<br>1792 | 85.8<br>1505 | 82.7<br>1286 | 79.1<br>1103 |
| .120 | | 119<br>6198 | 116<br>5420 | 110<br>4300 | 105.5<br>3410 | 101<br>2800 | 97.4<br>2310 | 93.0<br>1930 | 90.0<br>1633 | 86.5<br>1386 | 83.6<br>1198 |
| .125 | | | 130<br>6701 | 124<br>5232 | 119<br>4205 | 114<br>3393 | 109<br>2817 | 105<br>2354 | 101<br>1977 | 97.2<br>1679 | 93.8<br>1436 |
| .135 | | | | | 147<br>6080 | 141<br>4930 | 135<br>4060 | 130<br>3394 | 125<br>2820 | 121<br>2406 | 116<br>2035 |
| .148 | | | | | | 181<br>7802 | 175<br>6350 | 168<br>5250 | 163<br>4380 | 156<br>3705 | 151<br>3166 |
| .156 | | | | | | | 201<br>8238 | 193<br>6772 | 188<br>5646 | 181<br>4763 | 176<br>4074 |
| .162 | | | | | | | | 214<br>8150 | 207<br>6800 | 202<br>5706 | 195<br>4887 |
| .177 | | | | | | | | | | 258<br>8866 | 250<br>7485 |
| .187 | | | | | | | | | | | 289<br>9863 |

| Wire Dia. d. | OUTSIDE DIAMETER OF COIL — INCHES | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25/32 | 13/16 | 27/32 | 7/8 | 29/32 | 15/16 | 31/32 | 1 | 1 1/32 | 1 1/16 | 1 3/32 | 1 1/8 | 1 5/32 |
| | ← Load in lbs. at 100,000 psi — Wahl's Factor "K" included<br>← Spring scale per single coil | | | | | | | | | | | | |
| .037 | 2.50<br>6.56 | | | | | | | | | | | | |
| .039 | 2.94<br>8.17 | 2.82<br>7.20 | | | | | | | | | | | |
| .041 | 3.40<br>10.1 | 3.28<br>8.84 | 3.15<br>7.84 | | | | | | | | | | |
| .043 | 3.91<br>12.2 | 3.76<br>10.8 | 3.65<br>9.60 | 3.52<br>8.60 | 3.38<br>7.63 | | | | | | | | |
| .045 | 4.49<br>14.7 | 4.31<br>13.0 | 4.14<br>11.5 | 4.00<br>10.4 | 3.89<br>9.27 | 3.76<br>8.33 | | | | | | | |
| .047 | 5.11<br>17.8 | 4.93<br>15.6 | 4.73<br>13.8 | 4.57<br>12.4 | 4.39<br>11.0 | 4.27<br>9.89 | 4.14<br>8.99 | 4.00<br>8.09 | | | | | |
| .049 | 5.81<br>21.3 | 5.55<br>18.6 | 5.34<br>16.5 | 5.17<br>14.6 | 4.99<br>13.1 | 4.83<br>11.9 | 4.69<br>10.6 | 4.55<br>9.66 | 4.41<br>8.80 | | | | |
| .051 | 6.50<br>25.1 | 6.29<br>22.1 | 6.05<br>19.7 | 5.79<br>17.3 | 5.63<br>15.5 | 5.44<br>14.0 | 5.26<br>12.6 | 5.14<br>11.4 | 4.98<br>10.3 | 4.82<br>9.43 | | | |
| .054 | 7.72<br>31.7 | 7.39<br>27.8 | 7.14<br>24.9 | 6.92<br>22.1 | 6.65<br>19.7 | 6.47<br>17.6 | 6.28<br>16.0 | 6.06<br>14.5 | 5.86<br>13.1 | 5.73<br>11.9 | 5.55<br>10.8 | 5.41<br>10.0 | |
| .055 | 8.11<br>34.4 | 7.83<br>30.1 | 7.56<br>27.0 | 7.32<br>23.9 | 7.04<br>21.3 | 6.77<br>19.0 | 6.63<br>17.3 | 6.40<br>15.6 | 6.22<br>14.2 | 6.02<br>12.9 | 5.88<br>11.7 | 5.70<br>10.7 | 5.56<br>9.90 |
| .059 | 10.0<br>46.7 | 9.63<br>40.5 | 9.27<br>36.1 | 9.01<br>32.2 | 8.64<br>28.5 | 8.42<br>25.6 | 8.15<br>23.2 | 7.89<br>21.1 | 7.68<br>18.9 | 7.45<br>17.3 | 7.24<br>15.8 | 7.00<br>14.3 | 6.81<br>13.2 |
| .063 | 12.2<br>61.3 | 11.7<br>53.7 | 11.3<br>47.3 | 10.9<br>42.3 | 10.5<br>37.7 | 10.2<br>33.7 | 9.85<br>30.4 | 9.60<br>27.5 | 9.29<br>24.8 | 9.00<br>22.6 | 8.81<br>20.6 | 8.55<br>18.8 | 8.35<br>17.4 |
| .067 | 14.6<br>79.3 | 14.1<br>70.5 | 13.6<br>61.9 | 13.0<br>54.5 | 12.7<br>49.1 | 12.2<br>43.8 | 11.9<br>39.3 | 11.5<br>35.6 | 11.1<br>32.2 | 10.9<br>29.3 | 10.6<br>26.9 | 10.2<br>24.3 | 9.93<br>22.3 |
| .071 | 17.4<br>102 | 16.6<br>88.9 | 16.1<br>79.1 | 15.5<br>70.6 | 15.0<br>62.4 | 14.5<br>56.2 | 14.2<br>51.0 | 13.6<br>45.3 | 13.3<br>41.3 | 12.9<br>37.4 | 12.5<br>34.2 | 12.2<br>31.5 | 11.9<br>28.6 |
| .072 | 18.1<br>108 | 17.4<br>95.3 | 16.8<br>84.4 | 16.1<br>74.0 | 15.7<br>66.6 | 15.2<br>59.9 | 14.7<br>53.1 | 14.2<br>48.2 | 13.8<br>44.0 | 13.4<br>39.4 | 13.0<br>36.0 | 12.7<br>33.3 | 12.4<br>30.2 |
| .075 | 20.4<br>130 | 19.7<br>113 | 18.8<br>99.2 | 18.1<br>88.2 | 17.6<br>78.9 | 17.2<br>71.1 | 16.6<br>63.9 | 16.0<br>57.6 | 15.7<br>52.5 | 15.1<br>47.0 | 14.8<br>43.0 | 14.4<br>39.5 | 14.0<br>36.2 |
| .077 | 22.0<br>145 | 21.2<br>127 | 20.5<br>112 | 19.7<br>98.9 | 19.1<br>88.1 | 18.4<br>79.1 | 17.9<br>70.8 | 17.3<br>64.0 | 16.9<br>58.1 | 16.4<br>52.8 | 15.9<br>48.1 | 15.6<br>44.0 | 15.1<br>40.3 |
| .080 | 24.8<br>171 | 23.7<br>150 | 22.9<br>132 | 22.2<br>117 | 21.4<br>105 | 20.8<br>93.7 | 20.1<br>84.4 | 19.5<br>75.6 | 18.9<br>68.5 | 18.3<br>62.1 | 17.8<br>56.1 | 17.3<br>51.4 | 16.9<br>46.8 |
| .085 | 29.4<br>223 | 28.4<br>195 | 27.4<br>172 | 26.6<br>153 | 25.6<br>136 | 24.9<br>122 | 23.9<br>108 | 23.3<br>97.5 | 22.6<br>89.0 | 22.0<br>80.2 | 21.3<br>72.7 | 20.8<br>67.2 | 20.3<br>61.1 |
| .090 | 34.8<br>286 | 33.6<br>250 | 32.5<br>220 | 31.2<br>195 | 30.3<br>174 | 29.4<br>155 | 28.3<br>139 | 27.6<br>125 | 26.6<br>112 | 26.1<br>103 | 25.2<br>92.7 | 24.7<br>85.1 | 24.1<br>78.6 |
| .092 | 37.0<br>315 | 35.7<br>276 | 34.5<br>242 | 33.4<br>215 | 32.4<br>191 | 31.2<br>171 | 30.3<br>153 | 29.6<br>138 | 28.6<br>124 | 27.8<br>111 | 27.0<br>102 | 26.3<br>94.1 | 25.6<br>85.1 |
| .095 | 40.6<br>363 | 39.1<br>316 | 37.8<br>279 | 36.6<br>247 | 35.5<br>220 | 34.5<br>196 | 33.2<br>175 | 32.4<br>158 | 31.3<br>143 | 30.5<br>129 | 29.6<br>118 | 29.1<br>108 | 28.0<br>97.5 |
| .100 | 47.3<br>455 | 45.6<br>397 | 44.0<br>349 | 42.6<br>309 | 41.3<br>275 | 40.1<br>245 | 38.7<br>220 | 37.6<br>197 | 36.7<br>178 | 35.5<br>161 | 34.7<br>147 | 33.5<br>132 | 32.8<br>121 |
| .105 | 54.7<br>566 | 52.7<br>494 | 50.9<br>434 | 49.3<br>384 | 47.7<br>340 | 46.3<br>302 | 44.6<br>271 | 43.5<br>244 | 42.4<br>221 | 41.0<br>199 | 40.0<br>181 | 38.8<br>165 | 38.0<br>151 |
| .106 | 55.9<br>590 | 54.3<br>514 | 52.4<br>452 | 50.8<br>400 | 48.7<br>354 | 47.3<br>316 | 46.0<br>283 | 44.8<br>255 | 43.2<br>229 | 42.2<br>207 | 41.2<br>188 | 40.0<br>172 | 39.1<br>157 |
| .109 | 61.0<br>664 | 58.8<br>583 | 56.8<br>513 | 54.9<br>452 | 53.2<br>402 | 51.6<br>357 | 49.7<br>318 | 48.4<br>287 | 47.2<br>259 | 45.6<br>234 | 44.5<br>212 | 43.6<br>194 | 42.2<br>176 |
| .112 | 66.1<br>757 | 63.5<br>657 | 61.3<br>577 | 59.3<br>509 | 57.5<br>452 | 55.7<br>401 | 54.2<br>360 | 52.2<br>323 | 50.9<br>291 | 49.6<br>263 | 48.0<br>239 | 47.0<br>218 | 46.0<br>199 |
| .118 | 76.7<br>956 | 73.7<br>830 | 71.2<br>730 | 69.3<br>642 | 67.1<br>569 | 64.5<br>505 | 62.7<br>453 | 61.0<br>407 | 59.4<br>366 | 57.9<br>330 | 56.1<br>300 | 54.8<br>273 | 53.6<br>249 |
| .120 | 80.2<br>1028 | 77.7<br>898 | 75.1<br>789 | 72.6<br>693 | 70.2<br>613 | 68.0<br>546 | 66.1<br>488 | 64.3<br>438 | 62.7<br>395 | 60.5<br>355 | 59.1<br>323 | 57.7<br>293 | 56.0<br>269 |
| .125 | 90.7<br>1248 | 87.2<br>1083 | 84.8<br>945 | 81.9<br>832 | 79.2<br>733 | 76.8<br>651 | 74.6<br>587 | 72.5<br>525 | 70.6<br>473 | 68.2<br>426 | 66.6<br>387 | 65.0<br>350 | 63.1<br>321 |
| .135 | 112<br>1761 | 109<br>1535 | 106<br>1354 | 102<br>1176 | 98.8<br>1046 | 96.3<br>919 | 93.5<br>822 | 90.8<br>739 | 88.4<br>666 | 85.5<br>600 | 83.4<br>543 | 81.4<br>493 | 79.6<br>449 |
| .148 | 147<br>2717 | 142<br>2343 | 138<br>2060 | 133<br>1802 | 129<br>1583 | 125<br>1403 | 122<br>1240 | 119<br>1119 | 115<br>998 | 112<br>896 | 110<br>815 | 106<br>741 | 104<br>678 |
| .156 | 170<br>3462 | 165<br>2995 | 159<br>2619 | 155<br>2293 | 150<br>2030 | 146<br>1 87 | 141<br>1593 | 138<br>1412 | 134<br>1270 | 131<br>1146 | 127<br>1031 | 124<br>932 | 121<br>850 |
| .162 | 189<br>4200 | 183<br>3581 | 178<br>3134 | 172<br>2734 | 168<br>2421 | 162<br>2112 | 158<br>1881 | 153<br>1685 | 150<br>1512 | 146<br>1353 | 142<br>1225 | 139<br>1114 | 135<br>1002 |
| .177 | 241<br>6427 | 235<br>5504 | 227<br>4759 | 222<br>4150 | 215<br>3626 | 209<br>3215 | 204<br>2849 | 198<br>2526 | 194<br>2266 | 188<br>2035 | 183<br>1830 | 178<br>1664 | 174<br>1505 |
| .187 | 281<br>8388 | 273<br>7147 | 265<br>6221 | 258<br>5386 | 250<br>4735 | 244<br>4136 | 238<br>3684 | 231<br>3272 | 226<br>2935 | 219<br>2620 | 215<br>2345 | 209<br>2122 | 204<br>1921 |
| .192 | 303<br>9558 | 293<br>8184 | 284<br>7030 | 277<br>6128 | 269<br>5359 | 262<br>4712 | 256<br>4156 | 249<br>3694 | 244<br>3324 | 236<br>2950 | 232<br>2682 | 226<br>2407 | 220<br>2183 |
| .207 | | | 350<br>10204 | 341<br>8857 | 332<br>7721 | 322<br>6765 | 316<br>5951 | 307<br>5266 | 300<br>4710 | 293<br>4210 | 287<br>3781 | 279<br>3419 | 274<br>3086 |
| .218 | | | | 393<br>11491 | 381<br>9948 | 372<br>8712 | 364<br>7679 | 356<br>6781 | 348<br>6042 | 339<br>5372 | 332<br>4819 | 323<br>4359 | 317<br>3948 |
| .225 | | | | | 416<br>11653 | 408<br>10175 | 398<br>8924 | 388<br>7918 | 378<br>7052 | 371<br>6246 | 363<br>5654 | 353<br>5072 | 346<br>4583 |
| .244 | | | | | | | | 484<br>11805 | 473<br>10419 | 461<br>9257 | 454<br>8315 | 444<br>7462 | 434<br>6718 |
| .250 | | | | | | | | | 508<br>11841 | 494<br>10466 | 484<br>9326 | 474<br>8389 | 465<br>7573 |
| .263 | | | | | | | | | | 570<br>13443 | 559<br>11996 | 545<br>10728 | 533<br>9638 |
| .283 | | | | | | | | | | | | | 655<br>13907 |

as surface condition of wire, eccentricity of loading, or corrosion have a marked influence on the fatigue strength. It is customary, therefore, to include a factor of safety in the design, particularly where the spring is difficult to replace or breakage would be injurious to some important function. This factor should vary between 1.25 and 2 according to conditions, but a value of 1.5 should suffice for most purposes.

The value of the allowable stress range decreases as the upper limit is raised. For low minimum stresses, say up to 20,000 psi, the stress *range* is sometimes held constant for the sake of simplicity; for example, a limiting endurance range of 0 to 70,000; 10,000 to 80,000; or 20,000 to 90,000 psi. The resulting error is then absorbed by the factor of safety. For higher minimum stresses the range must be reduced.

### Initial Tension Considered

TENSION SPRINGS: The tables apply equally to tension springs. However, it is necessary to know the amount of initial tension wound into a spring before proceeding. Since this stress is identical to that provided by axial loading, the initial tension is, of course, included in the load values of the table.

Average working stresses for tension springs will, in general be lower than for compression springs. A value commonly used is 80 per cent, which factor should be applied to TABLE II for general use.

Sharp bends or offset loops will cause higher stresses in the end coils and may, therefore, be the governing factor in the determination of a safe stress. Offset loops also make it difficult to predict the spring load accurately at some predetermined length, inasmuch as the eccentricity causes bending in the first few coils at each end. Because the spring is not rigid in bending, the central axis of the spring gradually aligns itself with the line of action of the pull, thus eliminating the bending moment. But since the end coil must assume the full offset moment, and each succeeding coil a lesser amount, the coils do not separate uniformly, and the load from the initial tension appears gradually instead of immediately as in the case of axial loading. This makes calculation of the load at a given length difficult, particularly in short springs.

Torsional endurance limit, TABLE III, may be applied to tension springs in the same manner as for compression springs. However, it should be borne in mind that other factors may influence the life of a tension spring, among which are stress concentration in the loops, introduction of bending stresses due to the increase in the

| Wire Dia. d. | OUTSIDE DIAMETER OF COIL—INCHES | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 3/16 | 1 7/32 | 1 1/4 | 1 5/16 | 1 3/8 | 1 7/16 | 1 1/2 | 1 9/16 | 1 5/8 | 1 11/16 | 1 3/4 | 1 13/16 | 1 7/8 | 1 15/16 | 2 | 2 1/16 | 2 1/8 | 2 3/16 | 2 1/4 | 2 5/16 | 2 3/8 | 2 7/16 |
| .059 | 6.69<br>12.2 | 6.49<br>11.1 | 6.33<br>10.3 | ← Load in lbs. at 100.000 psi — Wahl's Factor "K" included<br>← Spring scale per single coil | | | | | | | | | | | | | | | | | | |
| .063 | 8.07<br>15.8 | 7.89<br>14.7 | 7.75<br>13.6 | 7.36<br>11.6 | | | | | | | | | | | | | | | | | | |
| .067 | 9.78<br>20.7 | 9.50<br>19.0 | 9.23<br>17.4 | 8.86<br>15.0 | 8.46<br>13.0 | | | | | | | | | | | | | | | | | |
| .071 | 11.6<br>26.4 | 11.2<br>24.0 | 11.1<br>22.4 | 10.5<br>19.1 | 9.97<br>16.4 | 9.59<br>14.3 | 9.21<br>12.6 | | | | | | | | | | | | | | | |
| .072 | 12.1<br>27.9 | 11.8<br>25.8 | 11.5<br>23.5 | 11.0<br>20.4 | 10.4<br>17.4 | 10.0<br>15.1 | 9.62<br>13.3 | | | | | | | | | | | | | | | |
| .075 | 13.6<br>33.2 | 13.3<br>30.3 | 12.9<br>27.9 | 12.4<br>24.0 | 11.8<br>20.7 | 11.2<br>17.9 | 10.9<br>15.8 | 10.4<br>13.8 | | | | | | | | | | | | | | |
| .077 | 14.7<br>37.0 | 14.3<br>34.1 | 14.1<br>31.6 | 13.3<br>26.6 | 12.8<br>23.0 | 12.2<br>20.0 | 11.7<br>17.6 | 11.3<br>15.4 | | | | | | | | | | | | | | |
| .080 | 16.4<br>42.9 | 16.1<br>40.1 | 15.7<br>37.0 | 15.0<br>31.5 | 14.2<br>27.0 | 13.7<br>23.5 | 13.1<br>20.5 | 12.6<br>18.2 | 12.2<br>16.0 | | | | | | | | | | | | | |
| .085 | 19.7<br>55.8 | 19.2<br>51.7 | 18.8<br>47.4 | 17.9<br>40.8 | 17.1<br>34.8 | 16.4<br>30.4 | 15.8<br>26.6 | 15.1<br>23.2 | 14.5<br>20.6 | 14.0<br>18.1 | | | | | | | | | | | | |
| .090 | 23.3<br>71.3 | 22.9<br>65.9 | 22.2<br>60.3 | 21.3<br>51.6 | 20.2<br>44.3 | 19.5<br>38.5 | 18.6<br>33.5 | 18.0<br>29.5 | 17.2<br>25.9 | 16.6<br>23.1 | | | | | | | | | | | | |
| .092 | 25.0<br>78.6 | 24.1<br>71.2 | 23.8<br>66.4 | 22.5<br>56.4 | 21.8<br>49.1 | 20.7<br>42.4 | 19.9<br>36.8 | 19.1<br>32.4 | 18.4<br>28.4 | 17.8<br>25.5 | 17.1<br>22.6 | 16.6<br>20.2 | 16.0<br>18.1 | 15.5<br>16.4 | | | | | | | | |
| .095 | 27.5<br>89.7 | 26.8<br>82.8 | 26.0<br>75.6 | 26.9<br>70.1 | 23.9<br>55.7 | 22.9<br>48.7 | 21.8<br>42.2 | 21.0<br>36.8 | 20.2<br>32.7 | 19.5<br>28.8 | 18.9<br>25.9 | 18.1<br>23.0 | 17.7<br>20.8 | 17.1<br>18.7 | 16.5<br>16.9 | 16.0<br>15.4 | | | | | | |
| .100 | 31.9<br>111 | 31.1<br>103 | 30.5<br>94.5 | 29.0<br>81.0 | 27.7<br>69.0 | 26.4<br>59.8 | 25.5<br>52.4 | 24.5<br>46.2 | 23.6<br>40.4 | 22.7<br>35.9 | 22.1<br>32.1 | 21.3<br>28.7 | 20.4<br>25.5 | 19.8<br>23.1 | 19.3<br>20.9 | 18.7<br>19.0 | 18.1<br>17.2 | | | | | |
| .105 | 36.9<br>138 | 36.2<br>127 | 35.2<br>117 | 33.6<br>99.3 | 32.0<br>85.3 | 30.7<br>73.6 | 29.3<br>64.3 | 28.3<br>56.2 | 27.2<br>49.7 | 26.3<br>43.8 | 25.3<br>39.1 | 24.4<br>35.0 | 23.7<br>31.3 | 22.9<br>28.2 | 22.3<br>25.8 | 21.8<br>23.4 | 21.1<br>21.3 | 20.5<br>19.5 | | | | |
| .106 | 38.0<br>144 | 36.9<br>132 | 36.2<br>121 | 34.6<br>103 | 32.9<br>88.6 | 31.6<br>76.5 | 30.1<br>66.5 | 29.3<br>59.1 | 28.1<br>52.1 | 27.2<br>46.0 | 26.1<br>40.9 | 25.2<br>36.6 | 24.5<br>32.8 | 23.6<br>29.4 | 22.8<br>26.6 | 22.1<br>24.1 | 21.7<br>22.2 | 21.1<br>20.2 | 20.4<br>18.4 | | | |
| .109 | 41.4<br>162 | 40.2<br>148 | 39.0<br>136 | 37.6<br>117 | 35.9<br>100 | 34.2<br>86.5 | 32.9<br>75.0 | 31.6<br>66.4 | 30.5<br>58.3 | 29.3<br>51.6 | 28.4<br>45.7 | 27.5<br>41.3 | 26.4<br>36.8 | 25.7<br>33.0 | 25.0<br>30.2 | 24.2<br>27.3 | 23.4<br>24.8 | 22.8<br>22.5 | 22.3<br>20.8 | | | |
| .112 | 44.6<br>182 | 43.8<br>167 | 42.4<br>152 | 40.8<br>131 | 38.6<br>112 | 37.3<br>97.7 | 35.8<br>84.5 | 34.2<br>73.7 | 33.2<br>65.4 | 31.8<br>57.6 | 30.7<br>51.7 | 29.8<br>46.0 | 28.8<br>41.5 | 27.7<br>37.1 | 27.0<br>33.5 | 26.2<br>30.5 | 25.4<br>27.7 | 24.7<br>25.4 | 24.1<br>23.1 | 23.4<br>21.1 | | |
| .118 | 52.0<br>227 | 51.0<br>209 | 49.6<br>192 | 47.5<br>164 | 45.3<br>139 | 43.2<br>121 | 41.8<br>106 | 40.0<br>93.0 | 38.5<br>81.1 | 37.1<br>72.2 | 36.0<br>64.4 | 34.5<br>56.9 | 33.7<br>51.4 | 32.6<br>46.4 | 31.6<br>42.1 | 30.7<br>37.8 | 29.8<br>34.5 | 29.0<br>31.6 | 28.0<br>28.7 | 27.2<br>26.3 | 26.8<br>24.3 | 26.0<br>22.3 |
| .120 | 54.8<br>245 | 53.3<br>225 | 52.2<br>207 | 49.9<br>176 | 47.3<br>150 | 45.5<br>130 | 43.9<br>114 | 42.1<br>99.7 | 40.8<br>87.9 | 38.9<br>77.0 | 37.8<br>68.6 | 36.5<br>61.6 | 35.2<br>55.3 | 34.2<br>49.4 | 33.1<br>44.7 | 32.0<br>40.5 | 31.4<br>37.1 | 30.5<br>33.9 | 29.4<br>30.7 | 28.6<br>28.1 | 28.1<br>25.9 | 27.4<br>24.0 |
| .125 | 61.7<br>292 | 60.5<br>269 | 58.8<br>246 | 56.2<br>209 | 53.9<br>180 | 51.3<br>155 | 49.4<br>135 | 47.7<br>118 | 45.7<br>104 | 44.3<br>92.1 | 42.6<br>82.0 | 41.4<br>73.3 | 39.9<br>65.6 | 38.5<br>59.0 | 37.6<br>53.3 | 36.3<br>48.3 | 37.7<br>51.3 | 34.5<br>40.1 | 33.4<br>36.6 | 32.5<br>33.6 | 31.6<br>30.8 | 30.7<br>28.4 |
| .135 | 77.2<br>410 | 75.6<br>376 | 73.5<br>344 | 70.1<br>291 | 67.2<br>251 | 64.5<br>216 | 62.2<br>188 | 59.8<br>163 | 57.6<br>145 | 55.6<br>128 | 53.3<br>113 | 52.0<br>101 | 50.0<br>90.7 | 48.2<br>81.1 | 47.2<br>73.9 | 45.5<br>66.4 | 44.3<br>60.9 | 43.2<br>55.3 | 41.9<br>50.4 | 40.8<br>46.4 | 40.0<br>42.5 | 38.8<br>38.9 |
| .148 | 101<br>611 | 99.1<br>561 | 96.3<br>514 | 91.9<br>437 | 88.0<br>375 | 84.4<br>322 | 81.2<br>279 | 78.3<br>244 | 75.7<br>214 | 72.6<br>189 | 70.5<br>168 | 67.4<br>148 | 65.7<br>133 | 63.5<br>120 | 62.0<br>109 | 60.1<br>99.0 | 57.9<br>88.8 | 56.7<br>81.1 | 55.1<br>74.3 | 53.6<br>68.2 | 52.6<br>62.8 | 51.0<br>57.4 |
| .156 | 117<br>770 | 115<br>709 | 113<br>651 | 107<br>546 | 103<br>471 | 98.6<br>404 | 94.8<br>351 | 91.4<br>306 | 88.3<br>269 | 84.7<br>237 | 82.3<br>211 | 79.8<br>187 | 76.9<br>168 | 74.9<br>151 | 72.4<br>137 | 70.0<br>123 | 68.4<br>112 | 66.3<br>102 | 64.3<br>93.2 | 63.0<br>85.2 | 61.2<br>78.2 | 59.6<br>72.0 |
| .162 | 131<br>918 | 129<br>844 | 126<br>769 | 120<br>651 | 115<br>554 | 110<br>478 | 106<br>414 | 102<br>361 | 98.5<br>317 | 95.2<br>279 | 91.5<br>247 | 88.7<br>219 | 86.1<br>196 | 83.0<br>175 | 80.8<br>161 | 78.7<br>145 | 76.1<br>131 | 74.3<br>119 | 72.0<br>109 | 69.9<br>99.3 | 68.4<br>90.9 | 67.0<br>84.8 |
| .177 | 170<br>1367 | 166<br>1245 | 163<br>1145 | 156<br>964 | 149<br>819 | 143<br>703 | 137<br>609 | 132<br>529 | 128<br>468 | 123<br>409 | 119<br>361 | 115<br>324 | 112<br>289 | 109<br>259 | 105<br>234 | 102<br>209 | 99.1<br>191 | 96.4<br>173 | 94.0<br>159 | 90.9<br>144 | 89.5<br>133 | 86.7<br>122 |
| .187 | 199<br>1758 | 194<br>1591 | 191<br>1470 | 183<br>1236 | 175<br>1054 | 168<br>895 | 162<br>778 | 156<br>676 | 150<br>591 | 145<br>520 | 141<br>463 | 135<br>408 | 131<br>364 | 128<br>329 | 123<br>295 | 121<br>269 | 116<br>240 | 114<br>221 | 111<br>202 | 108<br>183 | 105<br>168 | 102<br>155 |
| .192 | 215<br>1982 | 210<br>1866 | 205<br>1640 | 197<br>1386 | 190<br>1184 | 181<br>1007 | 174<br>873 | 168<br>761 | 162<br>666 | 156<br>582 | 151<br>515 | 147<br>460 | 142<br>408 | 137<br>367 | 134<br>331 | 129<br>298 | 126<br>269 | 122<br>245 | 120<br>226 | 117<br>207 | 113<br>186 | 111<br>173 |
| .207 | 267<br>2796 | 261<br>2534 | 255<br>2320 | 244<br>1955 | 235<br>1658 | 226<br>1405 | 217<br>1218 | 209<br>1058 | 202<br>930 | 195<br>817 | 188<br>716 | 182<br>637 | 177<br>569 | 172<br>509 | 166<br>457 | 162<br>413 | 158<br>375 | 153<br>340 | 150<br>310 | 145<br>281 | 141<br>258 | 138<br>237 |
| .218 | 309<br>3560 | 304<br>3258 | 297<br>2970 | 284<br>2480 | 273<br>2097 | 263<br>1787 | 252<br>1541 | 244<br>1333 | 235<br>1166 | 227<br>1026 | 220<br>905 | 213<br>801 | 207<br>714 | 199<br>637 | 194<br>577 | 189<br>519 | 184<br>468 | 178<br>424 | 174<br>386 | 169<br>353 | 164<br>324 | 161<br>297 |
| .225 | 339<br>4109 | 331<br>3753 | 323<br>3407 | 311<br>2851 | 299<br>2415 | 288<br>2070 | 276<br>1770 | 267<br>1531 | 258<br>1344 | 249<br>1178 | 241<br>1043 | 233<br>921 | 226<br>822 | 220<br>735 | 212<br>659 | 206<br>593 | 201<br>536 | 195<br>489 | 191<br>445 | 186<br>404 | 181<br>371 | 177<br>339 |
| .244 | 426<br>6051 | 415<br>5519 | 406<br>4988 | 390<br>4176 | 376<br>3498 | 362<br>2987 | 349<br>2562 | 338<br>2219 | 326<br>1935 | 314<br>1691 | 306<br>1488 | 296<br>1319 | 287<br>1179 | 279<br>1048 | 269<br>941 | 262<br>847 | 255<br>764 | 249<br>693 | 241<br>631 | 236<br>575 | 229<br>526 | 224<br>481 |
| .250 | 455<br>6842 | 446<br>6152 | 436<br>5640 | 419<br>4703 | 404<br>3953 | 389<br>3359 | 375<br>2874 | 363<br>2491 | 349<br>2169 | 339<br>1890 | 328<br>1667 | 317<br>1472 | 307<br>1306 | 298<br>1169 | 290<br>1051 | 282<br>943 | 273<br>853 | 266<br>770 | 260<br>700 | 252<br>641 | 247<br>586 | 240<br>537 |
| .263 | 522<br>8686 | 513<br>7904 | 508<br>7175 | 483<br>5970 | 466<br>4984 | 450<br>4249 | 432<br>3664 | 420<br>3125 | 404<br>2721 | 392<br>2379 | 379<br>2102 | 366<br>1845 | 355<br>1650 | 344<br>1464 | 335<br>1316 | 326<br>1180 | 317<br>1068 | 309<br>963 | 300<br>876 | 293<br>798 | 287<br>731 | 279<br>669 |
| .283 | 639<br>12432 | 626<br>11239 | 614<br>10199 | 592<br>8469 | 574<br>7086 | 551<br>6028 | 534<br>5154 | 516<br>4437 | 499<br>3836 | 484<br>3320 | 467<br>2919 | 455<br>2576 | 440<br>2281 | 427<br>2030 | 415<br>1820 | 404<br>1637 | 393<br>1474 | 383<br>1331 | 374<br>1210 | 363<br>1104 | 355<br>1007 | 348<br>924 |
| .307 | | | 799<br>15248 | 743<br>12530 | 719<br>10435 | 694<br>8830 | 671<br>7565 | 647<br>6425 | 630<br>5605 | 610<br>4845 | 588<br>4258 | 572<br>3739 | 558<br>3298 | 541<br>2951 | 525<br>2625 | 510<br>2364 | 501<br>2123 | 483<br>1923 | 472<br>1742 | 461<br>1589 | 450<br>1441 | 441<br>1318 |
| .3125 | | | | 779<br>13715 | 753<br>11444 | 730<br>9605 | 706<br>8143 | 680<br>7047 | 662<br>6051 | 641<br>5284 | 623<br>4611 | 601<br>4058 | 586<br>3586 | 568<br>3196 | 555<br>2842 | 540<br>2559 | 525<br>2313 | 512<br>2078 | 499<br>1892 | 488<br>1715 | 473<br>1568 | 463<br>1430 |
| .331 | | | | | 882<br>15207 | 854<br>12765 | 824<br>10785 | 798<br>9183 | 776<br>7984 | 750<br>6906 | 733<br>6048 | 712<br>5309 | 690<br>4716 | 673<br>4152 | 652<br>3713 | 638<br>3319 | 621<br>2988 | 604<br>2701 | 589<br>2449 | 575<br>2212 | 562<br>2020 | 545<br>1841 |
| .343 | | | | | 972<br>18101 | 941<br>15177 | 915<br>12833 | 884<br>10914 | 858<br>9429 | 831<br>8195 | 806<br>7139 | 787<br>6271 | 761<br>5535 | 742<br>4898 | 725<br>4370 | 704<br>3907 | 684<br>3515 | 671<br>3170 | 655<br>2869 | 639<br>2606 | 620<br>2375 | 605<br>2161 |
| .362 | | | | | | | 1058<br>16794 | 1027<br>14224 | 997<br>12293 | 964<br>10664 | 940<br>9207 | 917<br>8023 | 886<br>7162 | 864<br>6297 | 844<br>5653 | 818<br>5028 | 801<br>4518 | 780<br>4054 | 765<br>3655 | 746<br>3327 | 729<br>3026 | 713<br>2756 |
| .375 | | | | | | | 1166<br>19966 | 1132<br>16921 | 1099<br>14556 | 1067<br>12538 | 1038<br>10903 | 1009<br>9555 | 980<br>8426 | 954<br>7447 | 932<br>6652 | 910<br>5905 | 883<br>5281 | 867<br>4787 | 844<br>4302 | 822<br>3914 | 804<br>3551 | 785<br>3252 |
| .394 | | | | | | | | | 1262<br>18641 | 1224<br>16042 | 1190<br>13967 | 1161<br>12106 | 1127<br>10602 | 1096<br>9432 | 1068<br>8350 | 1043<br>7418 | 1022<br>6684 | 993<br>6040 | 974<br>5420 | 949<br>4912 | 926<br>4476 | 904<br>4052 |
| .4375 | | | | | | | | | | | 1587<br>23202 | 1546<br>20315 | 1504<br>17715 | 1472<br>15560 | 1433<br>13859 | 1395<br>12183 | 1363<br>11010 | 1334<br>9845 | 1307<br>8861 | 1280<br>8005 | 1249<br>7257 | 1219<br>6582 |
| .500 | | | | | | | | | | | | | | | 2073<br>26645 | 2025<br>23410 | 1976<br>20999 | 1938<br>18635 | 1897<br>16817 | 1854<br>15036 | 1819<br>13718 | 1783<br>12348 |
| .5625 | | | | | | | | | | | | | | | | | | | 2623<br>29977 | 2563<br>26894 | 2508<br>24232 | 2473<br>21885 |

| Wire Dia. d. | OUTSIDE DIAMETER OF COIL — INCHES | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2½ | 2 9/16 | 2 5/8 | 2 11/16 | 2¾ | 2 13/16 | 2 7/8 | 2 15/16 | 3 | 3⅛ | 3¼ | 3⅜ | 3½ | 3⅝ | 3¾ | 3⅞ | 4 | 4⅛ | 4¼ | 4⅜ | 4½ |
| .120 | 26.7<br>22.2 | ← Load in lbs. at 100,000 psi — Wahl's Factor "K" included<br>← Spring scale per single coil | | | | | | | | | | | | | | | | | | | |
| .125 | 30.2<br>26.2 | 29.4<br>24.2 | 28.7<br>22.5 | | | | | | | | | | | | | | | | | | |
| .135 | 37.9<br>36.2 | 36.8<br>33.3 | 36.0<br>31.0 | 35.4<br>28.8 | 34.5<br>26.6 | 33.8<br>25.0 | | | | | | | | | | | | | | | |
| .148 | 49.7<br>53.1 | 48.5<br>49.2 | 47.7<br>45.6 | 46.3<br>41.9 | 45.3<br>39.1 | 44.3<br>36.5 | 43.3<br>34.1 | 42.8<br>32.0 | 41.7<br>29.7 | 40.0<br>26.2 | | | | | | | | | | | |
| .156 | 58.5<br>66.3 | 57.0<br>61.3 | 55.5<br>56.7 | 54.2<br>52.7 | 53.3<br>48.9 | 52.1<br>45.0 | 50.9<br>42.6 | 49.8<br>39.8 | 48.7<br>37.2 | 47.0<br>32.6 | 45.1<br>28.8 | 43.4<br>25.6 | | | | | | | | | |
| .162 | 65.1<br>77.9 | 63.4<br>71.9 | 62.3<br>66.4 | 60.7<br>61.5 | 59.1<br>56.9 | 58.2<br>52.9 | 57.2<br>50.0 | 55.8<br>46.5 | 54.6<br>43.5 | 52.2<br>38.0 | 50.5<br>33.5 | 48.7<br>30.0 | 46.8<br>26.7 | | | | | | | | |
| .177 | 84.7<br>113 | 82.9<br>104 | 81.1<br>96.7 | 78.8<br>89.0 | 77.2<br>83.3 | 75.8<br>77.0 | 74.3<br>72.3 | 72.4<br>67.1 | 71.0<br>63.2 | 68.3<br>54.9 | 65.5<br>48.4 | 63.0<br>43.0 | 61.2<br>38.4 | 59.0<br>34.4 | 57.0<br>30.9 | | | | | | |
| .187 | 99.8<br>141 | 97.5<br>131 | 95.2<br>122 | 92.4<br>112 | 91.2<br>105 | 89.2<br>97.8 | 86.8<br>90.4 | 85.0<br>84.7 | 84.1<br>79.5 | 80.3<br>69.5 | 77.6<br>61.1 | 74.9<br>54.6 | 71.9<br>48.5 | 69.2<br>43.3 | 67.2<br>38.7 | 65.2<br>35.1 | 63.0<br>31.7 | | | | |
| .192 | 108<br>160 | 105<br>148 | 103<br>135 | 100<br>125 | 98.1<br>117 | 96.1<br>108 | 94.1<br>101 | 92.1<br>94.5 | 90.2<br>88.6 | 86.9<br>77.2 | 83.6<br>68.6 | 80.8<br>60.4 | 78.0<br>54.2 | 74.9<br>48.2 | 72.5<br>43.5 | 70.5<br>39.1 | 68.4<br>35.5 | 66.0<br>32.1 | | | |
| .207 | 134<br>218 | 132<br>202 | 129<br>187 | 125<br>172 | 122<br>160 | 120<br>149 | 118<br>139 | 115<br>130 | 113<br>121 | 109<br>107 | 104<br>93.6 | 101<br>83.1 | 97.2<br>74.1 | 94.5<br>66.2 | 91.2<br>59.5 | 88.1<br>53.7 | 85.2<br>48.5 | 83.3<br>44.1 | 80.7<br>40.1 | 78.3<br>36.6 | 76.0<br>33.5 |
| .218 | 156<br>271 | 153<br>250 | 150<br>234 | 146<br>216 | 144<br>201 | 140<br>186 | 137<br>173 | 135<br>161 | 131<br>149 | 127<br>133 | 122<br>117 | 117<br>103 | 113<br>91.0 | 110<br>82.6 | 106<br>73.9 | 103<br>66.3 | 100<br>60.4 | 96.6<br>54.6 | 93.5<br>49.5 | 91.4<br>45.1 | 89.1<br>41.6 |
| .225 | 173<br>314 | 168<br>288 | 165<br>266 | 162<br>249 | 157<br>229 | 154<br>212 | 151<br>198 | 147<br>184 | 144<br>173 | 139<br>151 | 134<br>134 | 129<br>118 | 124<br>104 | 121<br>94.0 | 116<br>83.6 | 113<br>76.2 | 110<br>68.6 | 106<br>62.1 | 103<br>56.5 | 100<br>51.8 | 97.9<br>47.2 |
| .244 | 218<br>443 | 214<br>408 | 208<br>376 | 205<br>350 | 199<br>322 | 195<br>302 | 192<br>280 | 188<br>262 | 183<br>243 | 177<br>213 | 170<br>188 | 165<br>167 | 158<br>148 | 153<br>131 | 148<br>118 | 144<br>106 | 139<br>95.9 | 135<br>87.3 | 132<br>79.4 | 128<br>72.5 | 125<br>66.7 |
| .250 | 235<br>492 | 229<br>454 | 225<br>419 | 219<br>388 | 215<br>359 | 209<br>331 | 205<br>310 | 203<br>292 | 198<br>270 | 191<br>237 | 183<br>208 | 177<br>184 | 170<br>163 | 165<br>146 | 159<br>131 | 154<br>118 | 150<br>106 | 145<br>96.3 | 141<br>87.9 | 138<br>80.1 | 134<br>73.3 |
| .263 | 273<br>615 | 266<br>566 | 261<br>523 | 254<br>482 | 250<br>448 | 244<br>416 | 240<br>386 | 234<br>358 | 229<br>336 | 221<br>293 | 213<br>256 | 206<br>230 | 197<br>203 | 191<br>180 | 184<br>161 | 180<br>146 | 174<br>132 | 168<br>119 | 164<br>108 | 160<br>99.5 | 155<br>90.6 |
| .283 | 338<br>849 | 331<br>778 | 322<br>718 | 316<br>663 | 309<br>616 | 304<br>572 | 296<br>530 | 292<br>494 | 285<br>460 | 276<br>405 | 263<br>352 | 256<br>314 | 247<br>276 | 238<br>247 | 228<br>219 | 223<br>199 | 216<br>180 | 210<br>162 | 204<br>148 | 197<br>134 | 194<br>123 |
| .307 | 429<br>1213 | 420<br>1113 | 409<br>1027 | 401<br>945 | 394<br>877 | 385<br>813 | 379<br>757 | 369<br>701 | 361<br>654 | 348<br>571 | 336<br>501 | 325<br>442 | 312<br>392 | 304<br>351 | 293<br>314 | 285<br>282 | 276<br>255 | 269<br>231 | 261<br>210 | 251<br>188 | 246<br>172 |
| .3125 | 453<br>1311 | 441<br>1205 | 432<br>1085 | 424<br>1021 | 413<br>947 | 407<br>876 | 397<br>816 | 391<br>759 | 381<br>705 | 368<br>617 | 355<br>541 | 341<br>478 | 330<br>424 | 320<br>377 | 309<br>338 | 301<br>304 | 290<br>273 | 281<br>248 | 274<br>224 | 266<br>205 | 258<br>187 |
| .331 | 534<br>1693 | 524<br>1555 | 514<br>1433 | 500<br>1315 | 491<br>1217 | 478<br>1127 | 471<br>1050 | 460<br>977 | 453<br>911 | 436<br>792 | 421<br>694 | 403<br>611 | 391<br>543 | 380<br>484 | 367<br>435 | 356<br>388 | 343<br>348 | 334<br>314 | 326<br>289 | 315<br>262 | 308<br>238 |
| .343 | 593<br>1982 | 581<br>1818 | 570<br>1675 | 554<br>1540 | 544<br>1425 | 531<br>1319 | 522<br>1226 | 510<br>1142 | 501<br>1059 | 483<br>925 | 466<br>810 | 451<br>714 | 433<br>633 | 420<br>563 | 408<br>503 | 394<br>452 | 382<br>404 | 372<br>370 | 362<br>333 | 350<br>301 | 341<br>278 |
| .362 | 692<br>2535 | 678<br>2322 | 665<br>2131 | 651<br>1958 | 634<br>1814 | 624<br>1681 | 613<br>1555 | 599<br>1449 | 589<br>1346 | 567<br>1171 | 547<br>1025 | 525<br>905 | 508<br>800 | 493<br>712 | 478<br>634 | 462<br>571 | 452<br>518 | 434<br>463 | 426<br>423 | 411<br>382 | 403<br>350 |
| .375 | 767<br>2960 | 752<br>2723 | 737<br>2497 | 722<br>2290 | 704<br>2124 | 691<br>1959 | 679<br>1820 | 663<br>1692 | 652<br>1575 | 628<br>1368 | 605<br>1195 | 585<br>1053 | 567<br>933 | 545<br>828 | 529<br>739 | 515<br>664 | 497<br>597 | 485<br>540 | 471<br>492 | 457<br>442 | 445<br>406 |
| .394 | 884<br>3714 | 865<br>3375 | 849<br>3117 | 832<br>2872 | 816<br>2656 | 795<br>2448 | 781<br>2268 | 769<br>2111 | 750<br>1955 | 722<br>1704 | 701<br>1487 | 677<br>1307 | 651<br>1159 | 631<br>1029 | 612<br>917 | 595<br>821 | 575<br>740 | 560<br>667 | 542<br>604 | 530<br>550 | 515<br>503 |
| .4375 | 1201<br>6005 | 1173<br>5471 | 1148<br>5013 | 1126<br>4647 | 1102<br>4243 | 1082<br>3935 | 1063<br>3644 | 1037<br>3377 | 1019<br>3132 | 980<br>2718 | 951<br>2367 | 919<br>2082 | 888<br>1835 | 860<br>1626 | 835<br>1450 | 804<br>1296 | 783<br>1166 | 763<br>1051 | 738<br>952 | 721<br>864 | 704<br>785 |
| .500 | 1742<br>11268 | 1711<br>10209 | 1675<br>9358 | 1649<br>8526 | 1617<br>7880 | 1584<br>7293 | 1555<br>6694 | 1528<br>6221 | 1500<br>5736 | 1451<br>4971 | 1396<br>4325 | 1356<br>3783 | 1310<br>3330 | 1268<br>2947 | 1229<br>2619 | 1193<br>2338 | 1160<br>2097 | 1129<br>1887 | 1092<br>1705 | 1065<br>1545 | 1041<br>1405 |
| .5625 | 2426<br>19853 | 2376<br>17946 | 2337<br>16388 | 2284<br>14987 | 2251<br>13751 | 2205<br>12643 | 2177<br>11654 | 2135<br>10761 | 2096<br>9957 | 2020<br>8541 | 1956<br>7412 | 1898<br>6471 | 1832<br>5686 | 1786<br>5022 | 1727<br>4442 | 1676<br>3962 | 1628<br>3546 | 1584<br>3188 | 1541<br>2868 | 1503<br>2597 | 1468<br>2359 |
| .625 | 3239<br>33289 | 3174<br>30171 | 3115<br>27445 | 3061<br>25008 | 3010<br>22872 | 2964<br>20962 | 2921<br>19268 | 2861<br>17748 | 2825<br>16386 | 2722<br>14045 | 2649<br>12135 | 2565<br>10551 | 2491<br>9240 | 2405<br>8130 | 2344<br>7192 | 2271<br>6394 | 2221<br>5710 | 2159<br>5121 | 2101<br>4608 | 2047<br>4162 | 1997<br>3773 |

helix angle under load, sagging of long horizontal springs, dynamic considerations under fast action, and offset loading. The effect of these factors on the life of a spring is not always easy to predict, and the uncertainty of a particular case is reflected in the choice of a factor of safety.

EXAMPLE: To illustrate the use of the tables, it is assumed that a steel spring is desired to work in a ¾-inch hole and to give a load of 10 pounds at its maximum compressed length of 1½ inches with a stress not to exceed 100,000 psi.

From the tables, the outside diameter of the spring is selected as 23/32-inch. Looking down this column it is seen that 0.059-inch wire will deliver a load of 10.8 pounds at a stress of 100,000 psi. Since this is the smallest wire size that will support the load required at the safe stress specified, it will give the minimum scale obtainable: 60.4 per single coil of wire. If a higher scale is desired it is necessary to continue down the list until the necessary stiffness is reached. Assuming in this case that a minimum scale is desired and that the clearance from the minimum working length is ⅜-inch, the solid length should not exceed 1⅛-inches. This will allow 19 total or 17 active coils of 0.059-inch wire to be used for a spring with squared and ground ends. The spring scale will then be 60.4/17 = 3.55 pounds per inch deflection, and the free length of the spring will be 1½ + 10/3.55 = 4 5/16-inches.

TABLE III

**Operating Stress Range***

(Wahl correction factor *K* included)

| Wire Diam. (inches) | Music Wire Alloy Steel Wire Valve Spring Wire (psi) | Hard-Drawn Steel Wire (psi) | Stainless Steel (18-8) Wire (psi) | Phosphor Bronze Wire (psi) |
|---|---|---|---|---|
| Up to 0.032 | 0 to 85,000 | 0 to 70,000 | 0 to 50,000 | 0 to 35,000 |
| 0.032 to 0.062 | 0 to 80,000 | 0 to 70,000 | 0 to 50,000 | 0 to 35,000 |
| 0.062 to 0.125 | 0 to 75,000 | 0 to 60,000 | 0 to 50,000 | 0 to 35,000 |
| 0.125 and over | 0 to 70,000 | 0 to 50,000 | 0 to 50,000 | 0 to 35,000 |

* Data from *The Mainspring*, Wallace Barnes Co.

MACHINE DESIGN'S

MATERIALS WORK SHEET

FILING NUMBER
**9.04**

# Aluminum Alloys

WROUGHT, R300 SERIES

## AVAILABLE IN:

**Alloy Hardclad R301:** Sheet and plate in O, W and T tempers; roll-formed shapes in O, W and T tempers

**Alloy R303:** Extruded shapes in O, T275 and T315 tempers; press forgings in T275 and T315 tempers

**Alloy R317:** Wire, rod and bar in O and T tempers; forging stocks; press forgings in T temper

**Alloy R361:** Sheet and plate in O, W and T tempers; extruded shapes in O, W and T tempers; roll-formed shapes in O, W and T tempers; tubing and pipe in O, W and T tempers; wire, rod and bar in O, W and T tempers

## CHEMICAL ANALYSES

| | Si | Fe | Cu | Mn | Mg | Cr | Zn | Ti | Pb | Bi | Al |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hardclad R301 (core) | 0.75-1.2 | 0.75 max | 4.0-5.0 | 0.70-1.2 | 0.25-0.55 | 0.25 max | 0.25 max | .. | .. | .. | [1] |
| Hardclad R301 (cladding) | 0.50-0.90 | 0.60 max | 0.10 max | 0.25 | 0.80-1.2 | 0.25 max | 0.10 max | 0.10 max | .. | .. | [1] |
| R361 | 0.40-0.80 | 0.70 max | 0.15-0.40 | 0.15 max | 0.80-1.2 | 0.15 | 0.10 max | 0.15 max | .. | .. | [1] |
| R303[3] | 0.50 max | 0.50 max | 0.80-1.8 | 0.10 max | 2.1-3.0 | 0.10-0.35 | 5.9 | .. | .. | .. | [1] |
| R317 | 1.0 max | 1.0 max | 3.5-4.5 | 0.40-1.0 | 0.20-0.80 | 0.25 max | 0.10[5] max | [2] | 0.30-0.70 | 0.30-0.70 | [1] |

[1] Aluminum and normal impurities constitute remainder.
[2] Zinc content for R317 in forging stock is 0.25 per cent maximum; titanium is 0.15 per cent maximum.
[3] Contains also 0.05-0.20 nickel, 0.10 max. vanadium.

## PROPERTIES

### ULTIMATE STRENGTH

| Form, Alloy and Temper | Thickness (in.) | Strength (psi) |
|---|---|---|
| **Sheet and Plate** | | |
| R301, O temper | up to 0.500 | 30,000 max |
| R301, W temper | up to 0.039 | 56,000 min |
| | 0.040 to 0.500 | 57,000 min |
| R301, T temper | up to 0.039 | 63,000 min |
| | 0.040 to 0.500 | 64,000 min |
| R361, O temper | up to 0.500 | 22,000 max |
| R361, W temper | up to 0.500 | 30,000 min |
| R361, T temper | up to 0.500 | 42,000 min |
| **Extruded Shapes** | | |
| R303, O temper | all | 35,000 max |
| R303, T315 temper | 0.040 to 0.600 | 75,000 min |
| | 0.601 and up | 80,000 min |
| R303, T315 temper | 0.040 to 0.600 | 70,000 min |
| | 0.601 and up | 75,000 min |
| R317, O temper | all | 35,000 max |
| R317, T temper | all | 50,000 min |
| R361, O temper | all | 22,000 max |
| R361, W temper | all | 26,000 min |
| R361, T temper | all | 38,000 min |
| **Roll-Formed Shapes** | | |
| R301, O temper | up to 0.249 | 30,000 max |
| R301, W temper | up to 0.039 | 56,000 min |
| | 0.040 to 0.249 | 57,000 min |
| R301, T temper | up to 0.039 | 63,000 min |
| | 0.040 to 0.249 | 64,000 min |
| R361, O temper | up to 0.249 | 22,000 max |
| R361, W temper | up to 0.249 | 30,000 min |
| R361, T temper | up to 0.249 | 42,000 min |
| **Tubing and Pipe** | **Outside Diam (in.)** | |
| R361, O temper | all | 22,000 max |
| R361, W temper | up to 8.00 | 30,000 min |
| R361, T temper | up to 8.00 | 42,000 min |
| **Wire, Rod and Bar** | **Size** | |
| R317, O temper | all | 35,000 max |
| R317, T temper | all | 55,000 min |
| R361, O temper | all | 22,000 max |
| R361, W temper | all | 30,000 min |
| R361, T temper | all | 42,000 min |
| **Press Forgings** | | |
| R317, T temper | | 55,000 min |
| R303, T275 temper | | 74,000 min |
| R303, T315 temper | | 70,000 min |

MACHINE DESIGN is pleased to acknowledge the collaboration of Reynolds Metals Co. in this presentation.

## YIELD STRENGTH

(*minimum*)

| Form, Alloy and Temper | Thickness (in.) | Strength (psi) |
|---|---|---|
| **Sheet and Plate** | | |
| R301, O temper | up to 0.500 | |
| R301, W temper | up to 0.500 | 37,000 |
| R301, T temper | up to 0.039 | 56,000 |
| R361, O temper | 0.040 to 0.500 | 57,000 |
| R361, W temper | up to 0.500 | 16,000 |
| R361, T temper | up to 0.500 | 35,000 |
| **Extruded Shapes** | | |
| R303, O temper | all | |
| R303, T275 temper | 0.040 to 0.600 | 70,000 |
| | 0.601 and up | 75,000 |
| R303, T315 temper | 0.040 to 0.600 | 65,000 |
| R317, O temper | all | |
| R317, T temper | all | 35,000 |
| R361, O temper | all | |
| R361, W temper | all | 16,000 |
| R361, T temper | all | 35,000 |
| **Roll-Formed Shapes** | | |
| R301, O temper | up to 0.249 | |
| R301, W temper | up to 0.249 | 37,000 |
| R301, T temper | up to 0.039 | 56,000 |
| | 0.040 to 0.249 | 57,000 |
| R361, O temper | up to 0.249 | |
| R361, W temper | up to 0.249 | 16,000 |
| R361, T temper | up to 0.249 | 35,000 |

| Tubing and Pipe | Outside Diam. (in.) | |
|---|---|---|
| R361, O temper | all | |
| R361, W temper | up to 8.00 | 16,000 avg. |
| R361, T temper | up to 8.00 | 35,000 avg. |

| Wire, Rod and Bar | Size | |
|---|---|---|
| R317, O temper | all | |
| R317, T temper | all | 32,000 |
| R361, O temper | all | |
| R361, W temper | all | 14,000 |
| R361, T temper | all | 35,000 |
| **Press Forgings** | | |
| R317, T temper | | 30,000 |
| R303, T275 temper | | 68,000 |
| R303, T315 temper | | 65,000 |

## ELONGATION IN 2 INCHES

(*minimum*)

| Form, Alloy and Temper | Thickness (in.) | Elong. (%) |
|---|---|---|
| **Sheet and Plate** | | |
| R301, O temper | up to 0.500 | 16 |
| R301, W temper | up to 0.039 | 14 |
| | 0.040 to 0.500 | 15 |
| R301, T temper | up to 0.039 | 7 |
| | 0.040 to 0.500 | 8 |
| R361, O temper | 0.010 to 0.020 | 14 |
| | 0.021 to 0.128 | 16 |
| | 0.129 to 0.500 | 18 |
| R361, W temper | 0.010 to 0.020 | 14 |
| | 0.021 to 0.249 | 16 |
| | 0.250 to 0.500 | 8 |
| R361, T temper | 0.010 to 0.020 | 8 |
| | 0.021 to 0.500 | 10 |
| **Extruded Shapes** | | |
| R303, O temper | all | 12 |
| R303, T275 temper | 0.040 to 0.600 | 7 |
| | 0.601 and up | 8 |
| R303, T315 temper | 0.040 to 0.600 | 7 |
| | 0.601 and up | 8 |
| R317, O temper | all | 12 |
| R317, T temper | all | 12 |
| R361, O temper | all | 20 |
| R361, W temper | all | 16 |
| R361, T temper | all | 10 |

## ELONGATION (Cont'd.)

| Roll-Formed Shapes | | |
|---|---|---|
| R301, O temper | up to 0.249 | 16 |
| R301, W temper | up to 0.039 | 14 |
| | 0.040 to 0.249 | 15 |
| R301, T temper | up to 0.039 | 7 |
| | 0.040 to 0.249 | 8 |
| R361, O temper | 0.010 to 0.020 | 14 |
| | 0.021 to 0.128 | 16 |
| | 0.129 to 0.249 | 18 |
| R361, W temper | 0.010 to 0.020 | 14 |
| | 0.021 to 0.249 | 16 |
| R361, T temper | 0.010 to 0.020 | 8 |
| | 0.021 to 0.249 | 10 |

| Tubing and Pipe | | Wall Thickness (in.) | | |
|---|---|---|---|---|
| | Outside Diam. (in.) | 0.025 to 0.049 | 0.050 to 0.259 | 0.260 to 0.500 |
| R361, W temper | 0.250-2.000 | 16 | 18 | 20 |
| | 2.001-8.000 | 14 | 16 | 18 |
| R361, T temper | 0.250-2.000 | 10 | 12 | 14 |
| | 2.001-8.000 | 8 | 10 | 12 |

| Wire | Size | Elong. |
|---|---|---|
| R317, O temper | up to 0.124 | |
| | 0.125 and up | 12 |
| R317, T temper | up to 0.124 | |
| | 0.125 and up | 16 |
| R361, O temper | up to 0.124 | |
| | 0.125 and up | 18 |
| R361, W temper | up to 0.124 | |
| | 0.125 and up | 18 |
| R361, T temper | up to 0.124 | |
| | 0.125 and up | 10 |

| Rod and Bar | Size | Elong. |
|---|---|---|
| R317, O temper | all | 12 |
| R317, T temper | all | 16 |
| R361, O and W tempers | all | 18 |
| R361, T temper | all | 10 |
| **Press Forgings** | | |
| R317, T temper | | 16 |
| R303, T275 and T315 tempers | | 10 |

## ENDURANCE LIMIT

(*typical, psi*)

| | |
|---|---|
| R301, T temper | 12,500 |
| R303, T temper | 22,500 |
| R317, O temper | 11,000 |
| R317, T temper | 18,000 |
| R361, O temper | 9,000 |
| R361, W temper | 13,500 |
| R361, T temper | 13,500 |

# PHYSICAL CONSTANTS

| | | R301 | R303 | R317 | R361 |
|---|---|---|---|---|---|
| Specific Gravity | | 2.80 | 2.82 | 2.81 | 2.70 |
| Weight (lb/cu in.) | | 0.101 | 0.102 | 0.102 | 0.098 |
| Coef. Thermal Expansion | | | | | |
| (average) | 68-212 F. | 0.0000122 | 0.0000129 | 0.0000122 | 0.0000130 |
| | 68-392 F. | 0.0000130 | 0.0000135 | 0.0000130 | 0.0000136 |
| | 68-572 F. | 0.0000138 | 0.0000144 | 0.0000138 | 0.0000141 |

| | Thermal Conductivity at 100 C (212 F) (Btu/in./ft²/deg F/hr) | Electrical Conductivity at 20 C (68 F) (% annealed copper, eq'l vol.) | Electrical Resistivity at 20 C (68 F) (microhm/cu cm) |
|---|---|---|---|
| R301, O temper | 1300 | 50 | 3.4 |
| R301, W temper | 1050 | 40 | 4.3 |
| R301, T temper | 1050 | 40 | 4.3 |
| R303, T temper | 800 | 30 | 5.7 |
| R317, O temper | 1200 | 45 | 3.8 |
| R317, T temper | 800 | 30 | 5.7 |
| R361, O temper | 1200 | 45 | 3.8 |
| R361, W temper | 1050 | 40 | 3.4 |
| R361, T temper | 1050 | 40 | 3.4 |

### SHEAR STRENGTH
*(typical, psi)*

| | |
|---|---|
| R301, O temper | 18,000* |
| R301, W temper | 34,500* |
| R301, T temper | 43,000 |
| R303, O temper | |
| R303, T temper | 47,500 |
| R317, O temper | 18,000 |
| R317, T temper | 38,000 |
| R361, O temper | 12,500 |
| R361, W temper | 24,000 |
| R361, T temper | 50,000 |

*Estimated values.

### BRINELL HARDNESS
*(typical, 500-kg load, 10-mm ball)*

| | |
|---|---|
| R303, T temper | 150 |
| R317, O temper | 45 |
| R317, T temper | 105 |
| R361, O temper | 30 |
| R361, W temper | 65 |
| R361, T temper | 95 |

## HEAT TREATING CYCLES

SOLUTION HEAT TREATMENT

| Alloy | Soaking Temp. (deg. F) | Quench | Temper[1] Designation |
|---|---|---|---|
| R301 | 930-950 | Cold water | W |
| R303[2] | 810-840 | Cold water[3] | None |
| R317 | 930-950 | Cold water | None |
| R361 | 960-980 | Cold water | W |

[1]When in the stable condition.
[2]Precipitation treatment should not be started until at least 24 hours after completion of solution heat treatment.
[3]Hot water for extra heavy forgings.

PRECIPITATION TREATMENT

| Alloy | Aging Temp. (deg. F) | Aging Time (hrs) | Temper Designation |
|---|---|---|---|
| R301 | 350±5 | 8 | T |
| | 320±5 | 18 | T |
| R303 | 315±5 | 8 | T315 |
| | 275±5 | 25 | T275 |
| R317 | Room | 96-120 | T |
| R361 | 320±5 | 18 | T |
| | 350±5 | 8 | T |

## BEND RADII

The following bend radii for sheet and plate are intended only as a guide in the selection of the minimum radius for a given material or the hardest alloy and temper for a given radius. Minimum permissible radii vary with the nature of the forming operation, the type of forming equipment, and the design and condition of the tools, and can be determined accurately only by actual trial under contemplated conditions of fabrication.

APPROXIMATE RADII FOR 90-DEGREE COLD BENDS

| Alloy and Temper | Approximate Thickness (t) in Inches 0.016 | 0.032 | 0.064 | 0.125 | 0.188 | 0.250 |
|---|---|---|---|---|---|---|
| R301-O | 0 | 0 | 0 | 0 | 0-1t | 0-1t |
| R301-W | 1t-2t | 1½t-3t | 2t-4t | 3t-5t | 4t-6t | 4t-6t |
| R301-T | 2t-4t | 3t-5t | 3t-5t | 4t-6t | 5t-7t | 6t-8t |
| R361-O | 0 | 0 | 0 | 0 | 0-1t | 0-1t |
| R361-W | 0-1t | 0-1t | ½t-1½t | 1t-2t | 1½t-3t | 2t-4t |
| R361-T | 0-1t | ½t-1½t | 1t-2t | 1½t-3t | 2t-4t | 2t-4t |

## TEMPERS

O TEMPER: Material in its softest and most workable condition. This temper is produced by annealing.

W TEMPER: Produced by solution heat treatment. Only R301 and R361 alloys in this group are stable in this condition.

T TEMPER: Produced by aging solution-heat-treated material.

F TEMPER: Material in its as-fabricated condition wherein there is an indefinite amount of strain hardening.

T275 TEMPER: Produced by solution heat treatment followed by artificial aging at 275 F for 25 hours. Applies only to R303.

T315 TEMPER: Produced by solution heat treatment followed by artificial aging at 315 F for 8 hours. Applies only to R303.

## CHARACTERISTICS

**R301:** A composite aluminum alloy, consisting of a high-strength core, clad on each face with a corrosion-resistant aluminum alloy of intermediate strength. It is stable in the W temper and can be worked any time after solution heat treatment and quenching. Compared to other high-strength aluminum alloys it has superior formability in the O and W tempers and equal or superior formability in the T temper. Its corrosion resistance is good in all tempers and its spot welding characteristics are excellent.

**R303:** Highest strength alloy of the R300 series. Of the zinc-magnesium type with small amounts of other alloying elements. Not stable in the W temper because it continues to age harden at room temperature for an indefinite period of time. Maximum strength in the stable condition is obtained by artificial aging, T275 and T315 being the two tempers produced. The latter has slightly greater formability and resistance to corrosion than the former.

**R317:** Essentially an aluminum-copper-maganese-magnesium alloy (17S) with small additions of other metals to improve machining characteristics. It age hardens at room temperature following solution heat treatment, therefore does not require elevated-temperature aging to develop high tensile and yield strengths. Inasmuch as cold drawing is not required to impart hardness and strength to the stock after heat treatment, the tendency for machined parts to warp during machining operations is greatly minimized. Greater uniformity in mechanical properties throughout the thickness of the stock is also realized for the same reason. This alloy is well suited to the general manufacture of aluminum alloy screw machine products.

**R361:** Intermediate strength alloy. Essentially an aluminum-magnesium-silicon-copper-chromium alloy. It is stable in the W temper and can be artificially aged to the T temper. Corrosion resistance highest and formability best of all alloys in the R300 series.

## APPLICATIONS

These alloys are particularly suited to machine parts requiring a combination of light weight, high strength and good machinability. Sheet stock is excellent for formed and drawn parts which must have good strength. Like other aluminum alloys, an excellent field of application is found in portable machines and in moving parts of all machines, alloy selection being based on the properties and characteristics demanded by each application.

## FABRICATION

### MACHINABILITY:

While all of these alloys machine without undue difficulty, R317 in T temper offers the best machinability of the series.

### FORGING:

In the design of forgings to be made of these alloys, all fillet and corner radii should be as large as practicable, thereby increasing die life and in many cases decreasing the number of forging operations required. A draft angle tolerance of plus or minus one degree for all outside surfaces, inside holes, ribs, etc., is allowed, with the usual draft angle being seven degrees.

**R301:** Not produced in forging stock.

**R303:** Press forges readily in temperature range of 700-800 F. Experience with press forgings and hammer forgings shows that the optimum forging temperature is about 750-780 F. When hammer forging, the forgeability of R303 is similar to 14S, although somewhat more power may be required in certain operations.

**R317:** Tests show that this alloy can be forged and that its use as a forging alloy offers advantages where forged parts having free machining qualities are desired. It also is possible that this alloy can be used for the manufacture of extruded shapes for applications where considerable machining is required.

**R361:** Seldom used as forging stock.

### FORMING:

**R301:** This alloy in W temper possesses better formability than any other aluminum alloy of equal or greater strength, making possible the forming of many parts now requiring 24S-O sheet and subsequent solution heat treatment and quenching. Use of R301-W, where possible, eliminates costly straightening operations experienced in the heat treatment of parts formed from 24S-O. Maximum strength of R301-T can be obtained by aging parts formed in R301-W without any distortion being encountered.

**R303:** Most frequently used in shapes where formability is not a factor.

**R317:** Machining stock. Formability not a factor.

**R361:** Excellent formability in all tempers. Where T temper cannot be used, W temper generally can be employed in severe forming operations and subsequently artificially aged to T temper without producing distortion.

### WELDING:

Since all alloys in the R-300 series develop their strength through heat treatment, welding should, wherever possible, be done before heat treatment. When welded in the W or T conditions, these alloys do not necessarily return to the fully annealed conditions as a result of the heat of welding. However, the strength of the parent metal in the vicinity of the weld is lowered considerably.

**R301:** In the heat treated condition, resistance welding is the only form of welding favorable to this alloy. Fusion welding not only produces a material having considerable reduction in strength, but also embrittles the metal in the area adjacent to the weld, and seriously impairs corrosion resistance.

**R303:** This alloy can be spot welded without undue difficulty, the strength of the welds being comparable to that of welds made with alloy 24S-T. In general, torch welding of this alloy is not recommended.

**R317:** Machining alloy. Welding generally not a factor.

**R361:** This alloy may be welded by either gas or resistance welding processes. Generally, it can also be welded by the metal-arc or carbon-arc process as well as by the atomic-hydrogen process. The inert-gas shielded-arc welding process, wherein the arc is shielded in an atmosphere of helium or argon, is likewise adaptable. Corrosion resistance is little affected by welding.

## RESISTANCE TO CORROSION

In general, these alloys do not corrode appreciably in dry, clean atmospheres. In marine and highly contaminated industrial atmospheres, anodic or other types of oxide treatments may be used, alone or supplemented by painting.

**R301:** The corrosion resistance of R301-W and R301-T sheet is markedly superior to that of 24S-T sheet and slightly inferior to that of Pureclad 24S-T sheet. Tests made on R301-W and R301-T sheet stressed up to 75 per cent of the yield strength and immersed in the standard salt-hydrogen peroxide solution have shown no susceptibility to stress-corrosion.

**R303:** Resistance of this alloy in the two T tempers to both general and intergranular corrosion is far superior to that of the aluminum-copper alloys of the dural type, such as 24S-T. Stressed and unstressed specimens of extruded R303-T315 have shown only negligible changes in appearance or tensile properties after six months exposure to the standard salt spray test. Under extreme conditions of exposure, use of the T315 temper offers the advantage of increased resistance to corrosion as well as better formability. R303 in both T tempers shows very satisfactory resistance to stress cracking, provided the heat treating and aging practices are conducted as recommended.

**R317:** Tests on R317-T indicate it is equal to 17S in resistance to corrosive attack.

**R361:** Has highest resistance to corrosion of all alloys in this group, being exceeded only by the non-heat-treatable aluminum alloys. Except in severe exposure conditions, it generally is not necessary to protect this alloy with surface finishes.

## GALVANIC CORROSION

Contact of these alloys—as of other aluminum alloys—with copper, nickel, brass, bronze, Monel, iron and steel should be avoided in the presence of corrosive enviroments such as salt water or sea coast atmosphere, because these metals are cathodic to alloys in the R-300 series and the resulting galvanic couple results in accelerated corrosion. Zinc and cadmium plated parts, however, can safely be used in contact with these aluminum alloys.

## MATERIAL DESIGNATIONS

| Alloy | Form | Federal | Army and Army Air Forces | Navy | Army-Navy (AN) Aeronautical | SAE | AMS |
|---|---|---|---|---|---|---|---|
| Hardclad R301 | Plate and sheet | .... | .... | .... | AN-A-22 | ... | ... |
| R303 | Extruded shapes | .... | .... | .... | AN-A-37 | ... | ... |
| R317 | Bar and rod | .... | AAF-1133OB AXS-1651 | .... | .... | ... | ... |
| R361 | Plate and sheet | QQ-A-327 | .... | 47A12b | .... | 281 | 4025A 4026A 4027A |
| R361 | Bar, rod, wire and shapes | QQ-A-325 | .... | 46A10d | .... | 281 | 4150 |
| R361 | Round tubing | WW-T-789 | .... | 44T30b | .... | 281 | 4080C 4082C |

# Assets to a Bookcase

### The Technology of Plastics and Resins

*By J. P. Mason and J. F. Manning, both of the department of chemistry, Boston University; published by D. Van Nostrand Co. Inc., New York; 493 pages, 6½ by 9½ inches, clothbound; available through* MACHINE DESIGN, *$6.50 postpaid.*

While few machine designers will find it necessary to make a painstaking study of the organic chemistry involved in plastics, there is much in the subject which is of value in appraising the properties of various plastics for specific machine parts. This book, while certainly not out of place on a chemist's book shelf, will nevertheless be of considerable assistance to any designer desirous of obtaining the greatest advantage from plastics applications.

This text covers the gamut of plastics—rubber through phenolics—discussing physical properties such as resistance to deformation and impact strength, as well as chemical properties such as solvent resistance, and acceptance of plasticizers. Covered also are such topics as plastics manufacture, fabrication, applications, and properties. The volume is a careful work, replete with tables and pertinent illustrations.

□ □ □

### Science and Life in the World

*Published by the McGraw-Hill Book Co. Inc., New York; three volumes, 586 total pages, 6¼ by 9¼ inches, clothbound; available through* MACHINE DESIGN, *$7.50 the set, postpaid.*

Presenting thoughts on current topics of outstanding interest as expressed by our leading scientists and educators, these three volumes bring together the addresses presented at the Westinghouse Centennial Forum held in 1946 in Pittsburgh. In the first volume the views of such men as Fermi, Oppenheimer, Chamberlain and Taylor concerning atomic energy and its future possibilities when applied to peace and war are recorded.

In the second volume, addresses covering two rather diverse fields are included—transportation and biology. Photosynthesis is brilliantly analyzed by Van Niel of Stanford, while biology in its varying aspects is discussed by Waksman, Pauling and Merck. The different phases of transportation are discussed by such qualified men as Kettering of General Motors and Clement of the Pennsylvania Railroad.

Addresses on a wide variety of subjects are incorporated in the concluding volume of the series. Karl Compton of the Massachusetts Institute of Technology comments on scientific and engineering progress, Jewett of the National Academy of Sciences discusses telephonic and radio communication, and Kellogg of the Edison Electric Institute gives an account of the development of industrial electric power.

While not "design" books, this series offers in a permanent form, thoughts which will certainly affect the men—and particularly the technical men—of our century to a great degree. It brings up to date outstanding developments in engineering and pure science, and presents in a clear manner the developments that may be expected in the not-too-distant future.

□ □ □

### Changing the Shape of Metals with an Engine Lathe

*Published by the Shell Oil Co. Inc., New York; 160 pages, 9 by 12¼ inches, clothbound; available through* MACHINE DESIGN, *$7.50 postpaid.*

Written to give even the most uninformed an accurate picture of the phenomenon of turning, this book presents a graphic, concise description of lathe operation. Commencing with a description of lathes, mentioning the various types, the book goes on to describe methods of holding the work, the function of different parts of the lathe, and the various types of cutting tools that may be used. This is followed by an excellent discussion of the various operations by which metal may be formed on a lathe—single-point turning, forming, knurling, tapering, boring, thread cutting, etc. The next section in turn covers typical machining problems, tracing each part through every operation to completion. The last section of the book deals with lubrication. It discusses the theory of metal cutting, the purpose of lubricants, and provides an excellent chart for the selection of cutting lubricants.

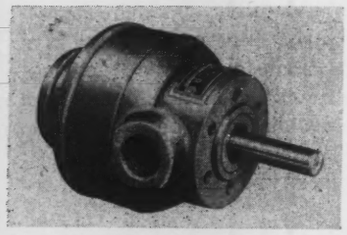
A number of other convenient charts are included in the appendix of the book, including cutting speeds, drill sizes, taper determinations, thread dimensions, and tap drill sizes. Although the designer may at no time have occasion to use an engine lathe, these and the other data covered in this interestingly prepared volume will without doubt assist materially in adding to his fund of design knowledge.

---

A pertinent commentary on the ever-present problem of welding materials, "Selection of Steel for Welding" by S. L. Hoyt is a readable, provocative discussion of problems experienced by the author in his many years of work in the metallurgy field. The booklet, which is a reprint of the 1945 Adams Lecture, discusses the relationship of general physical properties with weldability in the selection of steel for specialized applications. Bound in paper the booklet contains ten pages, measures 8 by 11¼ inches, and is available at 50c from the American Welding Society, 33 W. 39th St., New York 18.

# new parts and materials

## Hydraulic Pump



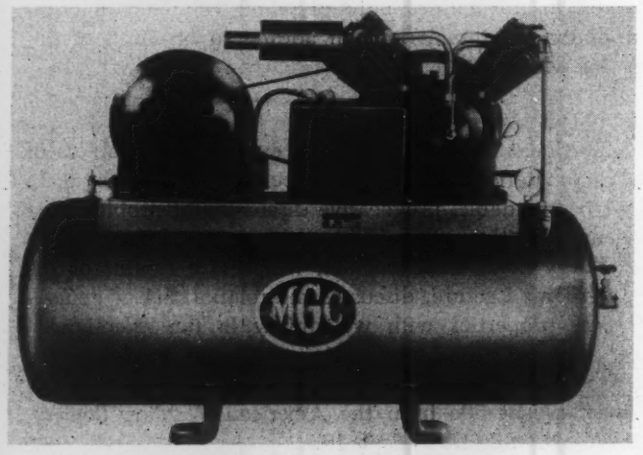
RECENTLY announced by the Gerotor May Corp., P. O. Box 86, Baltimore, Md., a new hydraulic pump may be utilized for operating loads up to 1500 psi intermittent or 1200 psi continuous pressures. The new series, known as QH, is available in capacities of 3, 5, 8 and 12 gpm for plain-base or flange mounting. Standard speed for the pump is 1200 rpm, although applications at other speeds are practical.

## Counters

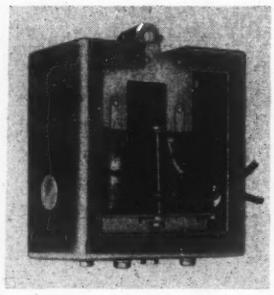
DOUBLE-DECK rotary and stroke counters, made in both conventional and predetermined types and designated as the N series, are now being manufactured by the Durant Manufacturing Co., 1933 N. Buffum St., Milwaukee 1. Rotary models have double-worm drive for smooth action and high speeds, while stroke models are so designed that the upper row is chain driven for quiet, easy operation at high speeds. Predetermined models have a simplified switch mechanism for light operation and positive-switch action at the predetermined count. Double-deck productimeter counters provide for register of current runs and daily, weekly, or monthly totals.

## Air Compressors

TWO-STAGE air compressors in five models have been developed by The Hobart Brothers Co., Troy, Ohio. The compressors are of the self-contained type with motor and compressor mounted on one-piece steel sub-base welded to an 80-gallon horizontal air receiver. They are fully automatic and controlled by centrifugal type unloading valves which eliminate the possibility of motor burnout. Power transmission is direct from heavy-duty motor by multiple V belts with slack take-up provided. Air pressure is automatically controlled. Compressors are available in 7, 9, 13 and 21 cubic-foot capacities and are furnished with 80-gallon storage tanks, a 60-gallon tank being optional with the 7 cubic-foot unit.




## Solenoids

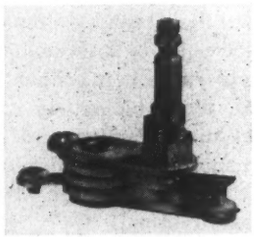


ALTERNATING-CURRENT solenoids of the bipolar type are now being marketed by the Automatic Switch Co., 41 E. Eleventh St., New York. Solenoids of this fully-laminated pull type have an unusual force stroke characteristic which, unlike that of conventional solenoids, is ascending with decrease in stroke. Sealed pull is extremely high owing to contact of two pole faces instead of one. The arrangement is said to provide practically ideal utilization of solenoid work output when applied to spring-loaded machine applications.

## Welding Electrode

ADDITION to its line of electrodes for welding nickel and nickel-copper alloys has been made by the Arcos Corp., 391 Gulf Bldg., Philadelphia 2. Trade-named Monend, the new electrode is used in welding wrought, cast, or clad Monel metal.

## Thermostat



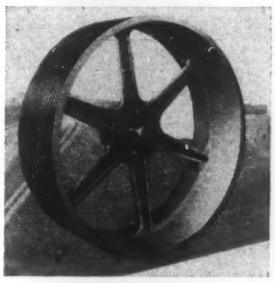
DESIGNED especially for applications requiring close temperature control and long life, a new thermostat manufactured by Stevens Mfg. Co., Mansfield, Ohio, is highly responsive and fully adjustable. The thermostat operates by means of an independent bimetal strip actuating the stainless steel or Inconel contact springs. Since the bimetal carries no operating current, inductive heating of the element is eliminated. Heavy-duty silver contacts are spot welded to the contact springs and units can be supplied

with either lava or mica insulation. Heating capacity of the thermostat is listed as 15 amperes, 115 volts, ac. Stems are available in a variety of lengths and styles.

## Cartridge Filters

CARTRIDGE-TYPE filter of laminated construction and cloth composition is now available from C. M. Fuller Co., 2043 Santa Fe Avenue, Los Angeles 21. Known as "Engine-Life" the filter is made in different cartridge sizes to fit all cases. Laminated construction and outside-to-inside flow is said to result in filtering effectiveness of maximum area for any given size. Fluid velocity is same throughout the filtering media resulting in uniform deposition of abrasives and contaminants on the filter cartridge.

## Sheaves

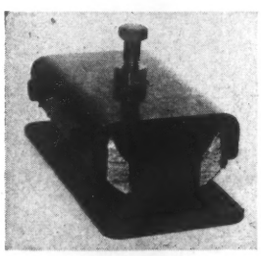


NOW AVAILABLE from the Worthington Pump & Machinery Corp., Harrison, N. J., are two new lines of QD sheaves featuring improved groove-belt fit and reinforced arm construction. Designated as the A and B lines, each will feature individual groove size to match belt size. Former non-matching combinations of sheaves have been discontinued. Reinforced arm construction of the new Worthington sheave incorporates a longitudinally-ribbed arm recessed down the middle. Advantage of this type of arm is that material is removed at or near the neutral axis where it adds little or no strength to the arm.

## Spiral Tubing

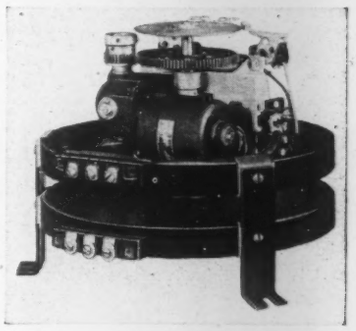
FOUR-PLY lock-seam spiral tubing in diameters from 2 to 8 inches is now available from Pratt Industries, Inc., Frankfort, N. Y. The tubing is spirally formed from metal strip with edges joined in a continuous seam.

## Vibration Mount



BOLT-ON TYPE vibration mount built around Goodrich R-10 Vibro-Insulator strip is now being marketed by Finn & Co., 2850 Eighth Ave., New York. The unit, which is known as RG Unit Vibration Isolator has a load range of 50 to 250 pounds and attains high efficiency by means of its rubber-in-shear arrangement. The mount has been used effectively for compressors, pumps, motors, kick presses, business machines, etc.

## Motor Drive for Rheostats



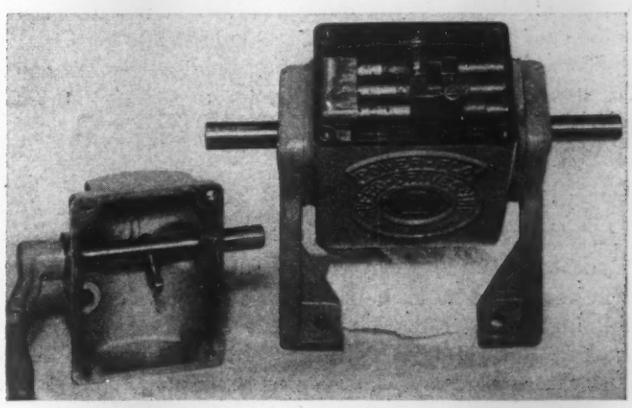
DESIGNED for remote and automatic operation of single or multiple stamped steel rheostats, a new compact motor-drive unit is now available from the Ward Leonard Electric Co., Mount Vernon, N. Y. The drive unit is available for ac and dc 115 or 230-volt operation with styles suitable for driving three-plate, 13-inch diameter rheostats. Standard units have 30 to 60 seconds travel from the all-resistance-in to the all-resistance-out position, and can be furnished for longer or shorter travel time.

## Clad Strip Steel

NOW AVAILABLE from Superior Steel Corp., Carnegie, Pa., is nickel and monel-clad strip. The composite steel strip is available in widths between one-quarter inch and ten and one-quarter inches and in thicknesses between 0.010 and 0.125 inch. In hot-rolled stock it is available in thicknesses between 0.095 and 0.25 inch. Strip is furnished with cladding on one or both sides, with standard cladding equal to 10 per cent of total thickness.

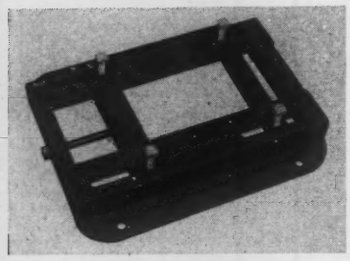
## Speed Reducers

COMPLETE LINE of selective speed reducers has been placed on the market by Speed-Drives, Inc., 23215 Hoover Rd., E. Detroit. The speed reducers, known as Power-Flo, have four speeds, the ratios being 1 to 1, 1¾ to 1, 3 to 1, and 4 to 1. Each model includes brackets designed for all types of machine installations. The drives are available in sizes from ½ to 20 hp. Positive full mesh of gears in each position is insured by the shifting mechanism which utilizes a ball and spring-locked device fitted in the case. Rigid machine-fitted guide rods and wide bearing surfaces hold the bronze shifting fingers in position under all load conditions. Drive may be



mounted on the bottom, top, front or back of a machine without changing the upright position of the case or shifting arm.

## Motor Slide-Base



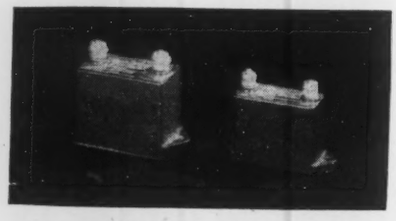
INTRODUCED by the Overly-Hautz Co., 11500 Madison Ave., Cleveland 2, is an all-steel motor-slide base available in sizes 203 to 505. The all-welded base is provided with holes for four hold-down bolts. Elongated slots are provided for mounting the motor which may be positioned by a transverse screw mounted at the base of the frame.

## Metal Coating

COATING for the preparation of aluminum and its alloys for painting and lacquering may be obtained from the Colonial Alloys Co., Ridge Ave. and Crawford St., Philadelphia. The material, known as Paintbond, is used by spraying or dipping.

## Capacitors

CAPACITORS of the Lectrofilm type in case styles 65 and 70 have recently been brought out by the Transformer Division of the General Electric Co., Schenectady, N. Y. The high-capacitance units are supplied in low-loss plastic cases especially adaptable for radio-frequency



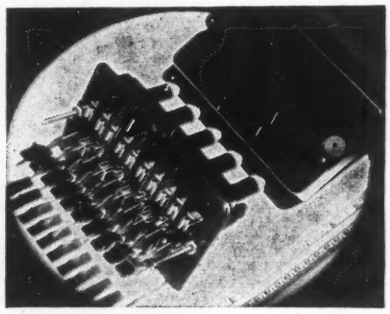
blocking and by-pass applications where Q and temperature co-efficients are not critical. Four ratings are listed in the case 65 style: 0.0001-$\mu\mu$f at 3000 volts dc, to 0.1-$\mu\mu$f at 500 volts dc. Four ratings are also listed in the case 70 style: 0.0001-$\mu\mu$f at 5000 volts to 0.1-$\mu\mu$f at 750 volts dc.

## Adhesive

SYNTHETIC, waterproof adhesive said to be more resistant to oxidation than natural rubber compounds has been developed by E. I. Du Pont de Nemours & Co. Inc., Wilmington 98, Del. This cement is recommended for bonding Buna-N type synthetic rubbers and vinyl films or stocks to rigid surfaces such as steel, aluminum, glass, wood or concrete. Designated as No. 5118 Fairprene Adhesive Cement, the new material is a thermoplastic synthetic elastic composition that does not require vulcanization to obtain maximum adhesive strength. Destroyed by aromotic hydrocarbons the bond is only slightly affected by oils or straight gasoline. It is unaffected by temperatures as low as 40 F but weakened at temperatures exceeding 160 F.

## Test Switch

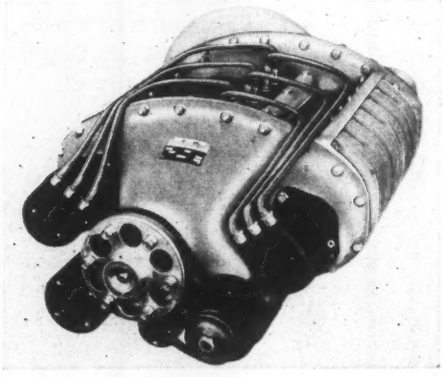
SWITCH placed on the market by the Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30., is a new unit for rapid accurate testing of switchboard instruments, meters and relays from the front of the board. Designed



with ten elements and rated at 250 volts 30 amperes, the switch is enclosed in a black plastic case with cover of similar material. The switch mounts semiflush on steel panels of any of the usual thicknesses. It is of the knife-blade type and is compact and pleasing in appearance.

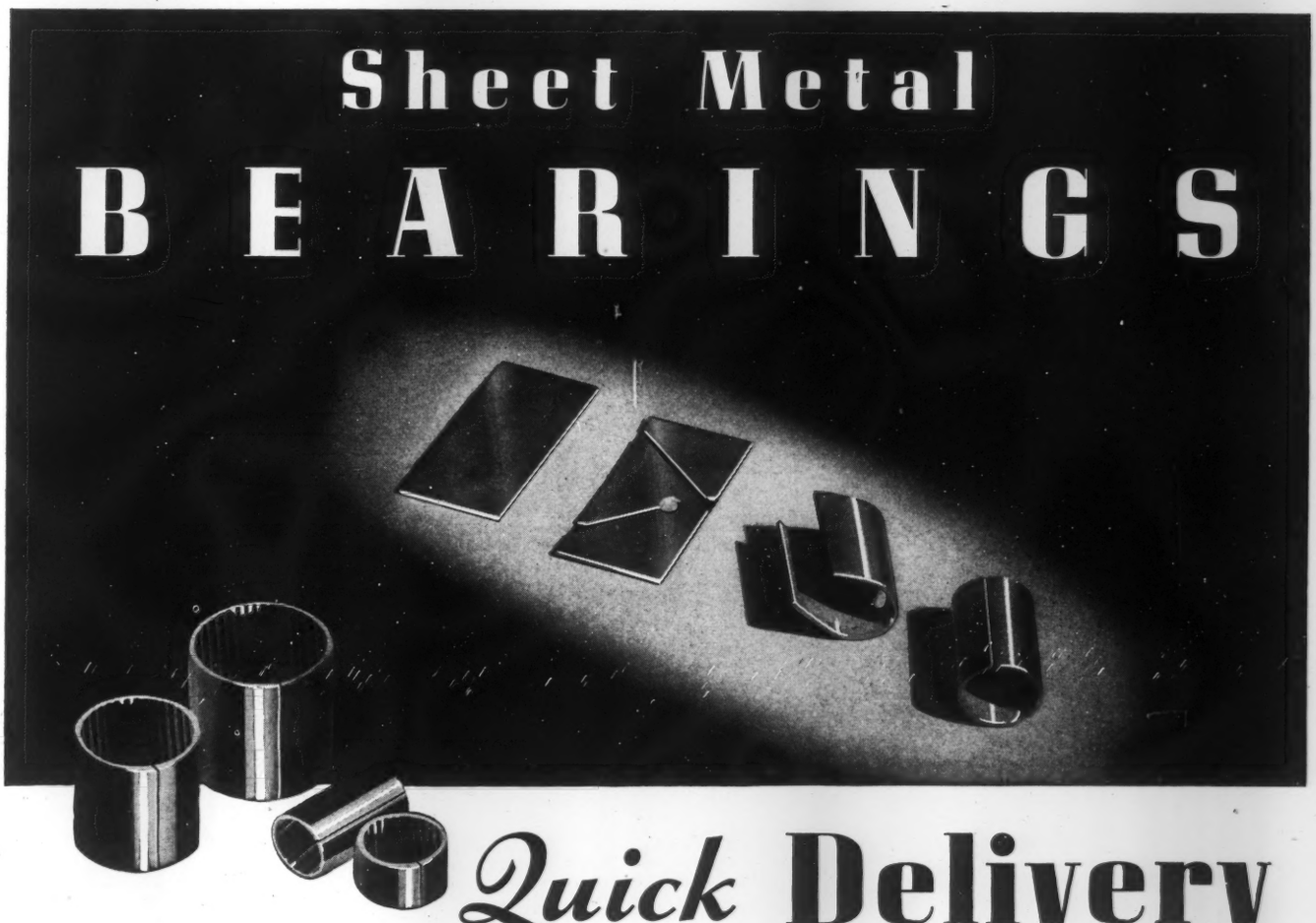
## Gasoline Engine

LIGHTWEIGHT gasoline engine designed for aircraft and marine use has been placed on the market by McCulloch Motors Corp., 6101 W. Century Blvd., Los



Angeles. Of two-cycle, opposed-piston, supercharged design, the 120-hp engine weighs only 150 lbs. Carburetion is by means of a fuel injector discharging gasoline into the inlet manifold through individual nozzles for each cylinder. Use of the injector permits normal operation of

# Sheet Metal BEARINGS



## *Quick* Delivery

*Engineers*
*Designers*

A handy file folder containing a wealth of useful, informative bearing data. Write for your copy TODAY.

It is no longer necessary to put up with expensive delays in securing thin wall bearings and bushings. Simply call in Johnson Bronze. We are now in a position to furnish your entire requirements, made strictly to your specifications in a matter of *days* . . . not weeks.

When you specify Johnson Bronze you are assured of getting top quality in every respect. We offer you a wide selection of materials . . . rolled bronze . . . bronze-on-steel . . . babbitt and steel. Our facilities for manufacturing these bearings are complete . . . our help is skilled, our experience dates back forty years.

Why not take advantage of this excellent opportunity to secure all your needs in top quality thin wall bearings without delay? Write, wire or call TODAY.

**JOHNSON BRONZE**

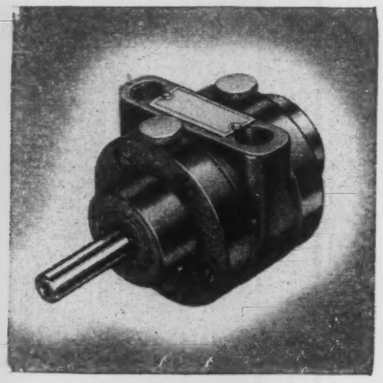
SLEEVE BEARING HEADQUARTERS

The MOST COMPLETE SLEEVE BEARING SERVICE in the WORLD

525 S. MILL STREET NEW CASTLE, PA.

the engine in any position. Main engine structure including integral cylinder block is an aluminum-alloy high-pressure die-casting. All bolts have heads and nuts of the same size, thus require only one wrench for disassembly.

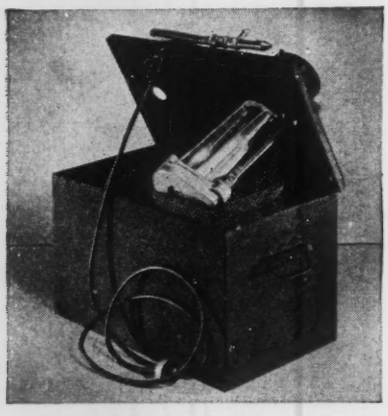
## Pneumatic Motor



INTRODUCED by the Gast Mfg. Co., Benton Harbor, Mich., a new model in their line of explosion-proof air motors may be used on portable or stationary equipment. Motor will start in any position, is said not to spark nor burn out due to overload or sudden braking. It runs under constant speed without stalling, with speed varying from 0 to 6000 rpm, horsepower from 0 to 1/6. The motor weighs 2½ pounds and is 2¼ inches in diameter.

## Coolant System

SELF-CONTAINED filtering system designed to remove particles from liquid coolants used on machine tools is now available from Inject-A-Flow Pump Co., 67 No. Willow St., Montclair, N. J. The system consists of a 7-gallon rectangular steel tank in which a Strainco strainer



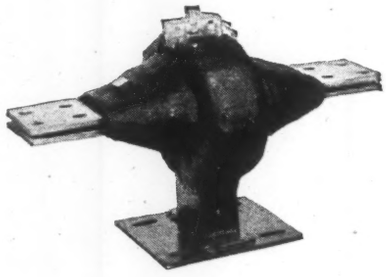
unit is mounted. Pump is mounted on the inside of the tank lid. The unit consists of a precision-cast noncorrosive centrifugal pump connected to the motor through a shaft. Provision is made for recirculating coolant liquid.

## Counters

ADDITION of new designs of two and three-shift pick counters to its line of counting and measuring machines has been made by the Durant Mfg. Co., 1933 No. Buffum St., Milwaukee 1. The counters are designed to meet varied requirements of mill men for long, hard usage. Special feature is the shutter mechanism which positively prevents any falsification or build up of figures. Any attempt to change count results in the shutter closing and concealing figures. Counter is resettable from either side, has a center drive and is interchangeable for right or left-hand looms.

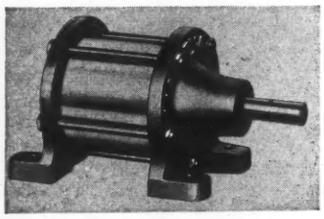
## Current Transformers

TWO NEW CURRENT TRANSFORMERS for meter, relay and control device applications have been announced by the Meter and Instrument Division of the General Electric Co., Schenectady 5. Both types have been designed for accurate metering over the normal current range up to 100 per cent of rating, and also for relay operation



up to 20 times rated current. Type JKL-3 is rated 5000 volts, 1200 to 4000 amp, and is designed to withstand full-wave impulse tests at 60 kv in accordance with ASA standards. Type JKL-4 is rated 8700 volts, 1200 to 4000 amp, and is designed to withstand full-wave impulse tests at 75 kv.

## Pneumatic Cylinder



LINE of air cylinders designed to expedite material holding operations may now be obtained from Air-Trol, 2651 W. Lake St., Chicago 12. Features of the new cylinders are said to include true bore, nonrusting heads and graphite-impregnated bronze ram bushings. Sizes available range from 1½ inches up, with the power rating upward of 1.76 times air line pressure.

## Hydraulic Control System

DEVELOPMENT of a remote control for use with hydraulic equipment recently has been made by Air Associates, Inc., Teterboro, N. J. The unit, known as the Hydro-Switch System, is composed of either a small panel or pedestal-mounted switch and a new type valve located near the

—you'll buy *Magnesium Lightness too!*

DOWMETAL

DOW

Consult Dow, the nation's pioneer producer, on applying magnesium to products. Dow supplies manufacturers with Dowmetal Magnesium Alloys in ingots; billets; sand, permanent mold and die castings; extrusions; forgings; sheet, plate and strip.

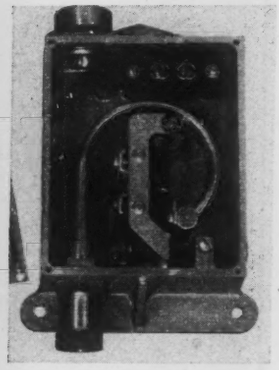
MAGNESIUM DIVISION • THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN

New York • Boston • Philadelphia • Washington • Cleveland • Detroit • Chicago • St. Louis • Houston • San Francisco • Los Angeles • Seattle

Dow Chemical of Canada, Limited, Toronto, Ontario

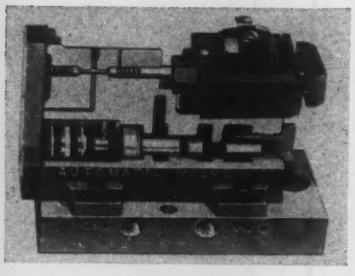
equipment to be moved. The device does not depend on pressure for operation but utilizes hydraulic flow to provide an all-hydraulic system. Two lines with a small drain line connected to the nearest hydraulic return provide four-way operation. While lines between switch and valve of the hydro-switch can be of any size, it is not necessary for them to be larger or heavier than 1/8 inch. The system provides for accurate control of the device being operated and does not prevent sequence operation of equipment. It is not limited to any particular operating pressure.

## Pressure-Operated Switch



LATEST addition to the line of pressure - operated switches manufactured by Meletron Corp., 950 N. Highland Ave., Los Angeles 38, is the new Series 310 designed to operate within a range of 20 to 3000 psi. Units carry an electrical rating of 10 amperes at 125 volts ac and can be readily installed in most industrial systems. The electrical connection is for one-half inch threaded conduit with screw terminals enclosed within the housing. Pressure connection is female ¼-inch NPT. Enclosed in a sturdy aluminum case, switch may be adjusted externally without removing cover or disturbing the mounting.

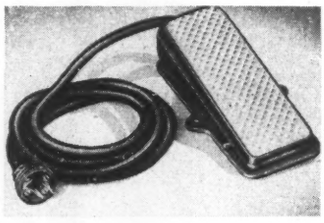
## Solenoid Air Valve



FOUR-WAY, four-port, solenoid-operated pneumatic valve with positive high-speed operation which is said to be especially suitable for controlling machine air cylinders has been placed on the market by Automatic Valve, Inc., 37415 Grand River Ave., Farmington, Mich. The valve, known as Model SV-4, is of the pressure-sealed, poppet-shuttle type. Solenoid plunger travel is ⅛ inch and valve is available in sizes ¼, ⅜, ½, and ¾ inch. Operating power values are 1.42-ampere in-rush at 110 volts, 60 cycles.

## Foot Switch

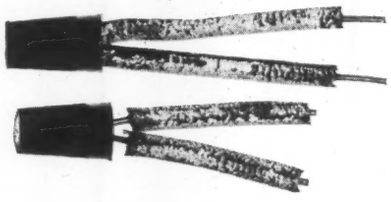
PEDAL TYPE foot-operated switch for series circuits only, suitable for use with timers or other controls has been announced by Electronic Controls, Inc., 44 Summer Ave., Newark, N. J. The switch is sturdily constructed of cast aluminum, and screwholed to permit fastening to floor or machine. Treadle is diamond plate of nonslip type and switch is furnished with heavy, approved rubber cord terminated in nonshattering male plug. Switch mechanism



is high quality snap action type available in either single-pole single-throw, normally-open or normally-closed; or single-pole double-throw models. Switch mechanism is easily replaceable, and power handling capacity is 1000 watts at voltages to 220 volts ac or 32 volts dc, noninductive loads.

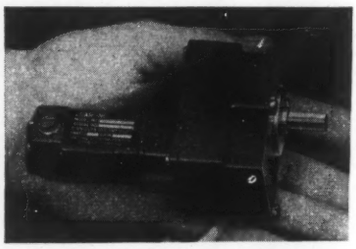
## Wire Connector

SOLDERLESS and tapeless wire connector, eliminating the need of more than one size connector, has been developed by the Holub Industries, Inc., Sycamore, Ill. The new type connector has been approved for joining 46 different wire combinations ranging from 2 No. 18



to 4 No. 14 wires with 1 No. 18 or 2 No. 12 with 1 No. 16 solid or stranded wires. The use of one connector for all common joints avoids confusion, increases efficiency and keeps down inventory.

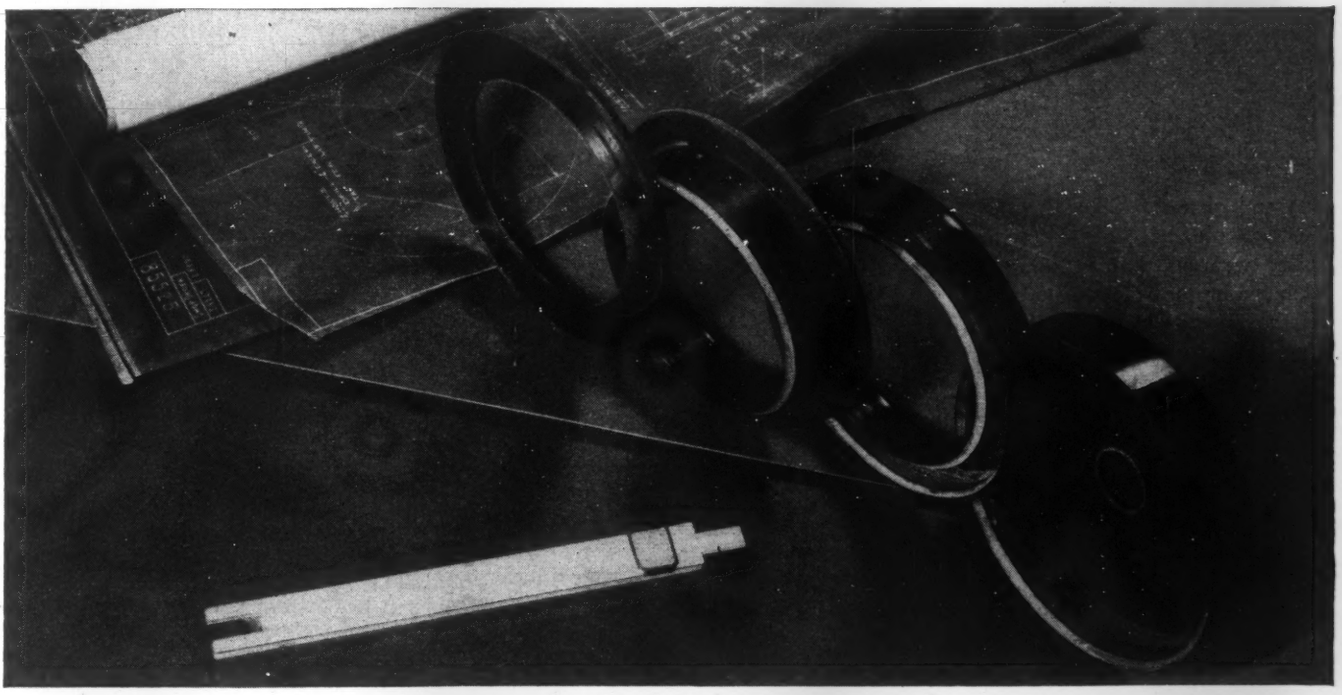
## Rotary Actuators



LIGHTWEIGHT rotary actuator Model 182 is the latest in the series of actuators built by Lear, Inc., Grand Rapids, Mich. The new unit has an overall length of approximately five inches, and worms, worm gears and helical gears are housed in a shell at one end of the unit. A multiple nonreversing limit switch may be incorporated for any number of positions up to 16. Multiple reversing rotary limit switches may be in-

# This 20-year diary proves the sound basic design and long life of

# VIM LEATHER PACKINGS



How would you like to have a stranger walk into your office and show you a record, dating back twenty years, of each machine in his shop and how it performed?

If you designed those machines you'd be much interested. We certainly were in this instance, because the diary this master mechanic brought us was a complete history of packing life on many presses.

Leather, both mineral and oak-tanned, had competed against rubber, and you can imagine which won. It was VIM, of course—the special mineral tannage originated by Houghton some 40 years ago. Press after press proved the superiority of VIM tannage and VIM design, by showing service records ranging from two to sixteen years without packing failure. You'll find the whole story in the February issue of "The Houghton LINE"—write for it.

## . . . A COMPLETE LINE

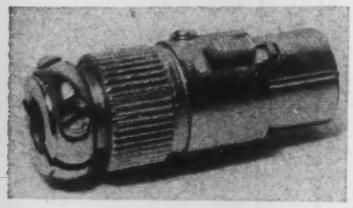
To the well known VIM Leather line we have added Vix-Syn synthetic rubber packings, homogeneous and fabricated, including "O" rings which are increasingly popular. Houghton therefore has a complete line for all hydraulic and pneumatic applications, backed by engineering service that design men like. E. F. HOUGHTON & CO., 303 W. Lehigh Ave., Philadelphia 33, Pa., and all principal cities

HOUGHTON'S

VIM LEATHER AND VIX-SYN PACKINGS

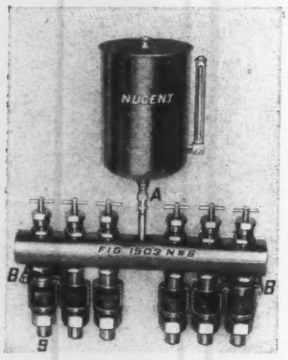
corporated for any number of positions up to 8. Torque output rating, depending on combination of motor size and overall gear reduction varies between 15 and 65 pound-inches. Among the applications for which these units have been designed are: Actuation of special locking devices, balanced or butterfly type shutters, radio tuning, computing and indexing machines, and aircraft control.

## Microphone Connector



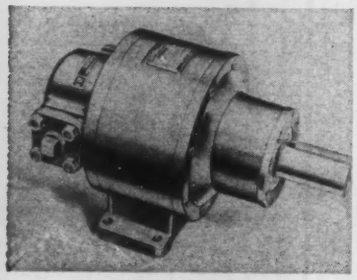
MATING WITH standard XL zinc receptacles, a new series of microphone shell plugs developed by Cannon Electric, 3209 Humboldt St., Los Angeles 31., is made with steel shells and integral clamps. The new plug, carrying the designation SC, is somewhat smaller in length than corresponding zinc plug types and has a minimum cable entry of ¼ inch and a maximum of 5/16 inch. Ampere rating is 15. Minimum flashover voltages are given as 1500, while standard working voltage is given as 250.

## Multiple Oiler




ADDITION to the line of lubrication specialties manufactured by Wm. W. Nugent & Co., Inc., 410-412 N. Hermitage Ave., Chicago 22, is a new heavy-duty multiple oiler. The new unit has a reservoir tank capacity of three pints and is available with a string of sight-feed valves in multiples of from 2 to 23 feeds. It is designed to be used on any machine requiring drop feed or small stream lubrication. The oilers have removable strainers in each sight feed which, together with the glass, may be removed for cleaning without stopping oil flow.

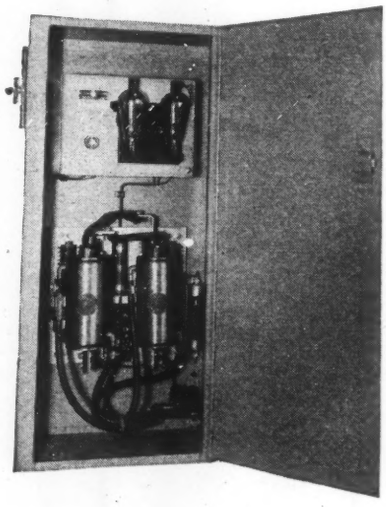
## Hydraulic Pump



LIGHTWEIGHT hydraulic pump deloping 5000 psi now is being made by the Superdraulic Corp., Dearborn, Mich. The pump, known as the Superdraulic Junior, is practically a duplicate of the 40-hp Superdraulic pump previously announced in this department. The unit is, however, only six inches in diameter, 11 inches long and weighs only 35 lb. Three gallons per minute are delivered at 1800 rpm and two gallons per minute at 1200 rpm.

## Welding Control

LINE OF non-synchronous electronic resistance-welding control combinations is now available from the Control Division of the General Electric Co., Schenectady, N. Y. New line, designed to meet the new NEMA standards for resistance-welding controls, includes combinations of ignitron contactors and sequence-weld timers with or without electronic heat control. All units are mounted in



a single cabinet. The ignitron contactors are said to offer high-speed operation and flexibility. Sequence-weld timers give accuracy of timing regardless of normal time-voltage variations because voltage-regulation tubes are used in the timing circuit. The use of industrial type relays, cabled wiring and plug-in timing panel and accessories simplifies servicing and increases flexibility of the control unit.

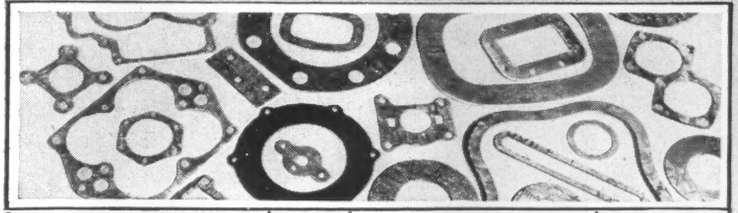
## Booster Cylinder

OIL-OPERATED hydraulic booster cylinder for air operated controllers is offered by the Askania Regulator Co., 1603 S. Michigan Ave., Chicago 13. The unit provides high power amplification and permits exact positioning of heavy dampers, valves and similar units in accordance with applied pneumatic loading pressure, usually 0-15 psi. Cylinders are available up to 8-inches inside diameter and 30-inches stroke.

## Temperature Control

CLOSE CONTROL of temperature with the variations as low as 1/5-degree Fahrenheit is accomplished with the new Xactline temperature control developed by Claud S. Gordon Co., 300 S. Wallace St., Chicago 16. The new

# Choose the RIGHT Gasket



## from these 14 Basic Materials

| Recommended For | Style No. | Description | Thickness |
|---|---|---|---|
| General service against superheated steam, air, hot or cold water, ammonia, oil, etc. | 60 | Long-fiber asbestos and wear-resisting compounds bonded under heat | 1/64" to 1/4" |
| Process industries, and wherever protection from discoloration is necessary | 61 | Same as style No. 60 except white in color | 1/64" to 1/4" |
| General service against gas and air, or where a comparatively soft material is required | 50 | A compressed asbestos fiber sheet, softer and less dense than Stylе No. 60 | 1/64" to 1/4" |
| Same service as Style No. 60 | 70 | Similar to Style No. 60 but harder and denser | 1/64" to 1/4" |
| General service where a gasket of high dielectric value is required | 71 | Special, long-fiber asbestos impregnated with a bonding compound high in dielectric values | 1/64" to 1/4" |
| Service against hot oils, petroleum solvents, refrigerants | 76 | Long-fiber asbestos bonded with synthetic rubber | 1/64" to 1/4" |
| Rough flanges against low, medium or high pressure steam, air and water | 100 | Asbestos-metallic cloth impregnated with a rubber heat-resisting compound | 1/32" to 1/4" |
| Gasoline and hot oil service | 98 | Similar to Style No. 100 but impregnated with a synthetic rubber compound | 1/32" to 1/4" |
| High temperature and pressure service, especially on marine engines | 101 | A strong asbestos fabric interwoven with fine brass wire | 1/32" to 1/4" |
| Gasoline, benzine, oil greases, hot or cold water. Temperature limit 250°F. | 711 | A dense plant fiber gasket of very high tensile strength | .01", 1/64", .02", 1/32", 1/16",3/32", 1/8", 3/16" |
| High temperature service on flanges and other parallel surfaces | 219 | Long-fiber asbestos felted and bonded with a heat-resistant rubberless binder | 1/32" to 1/4" |
| Flange service against most acids where a very soft gasket is required | 83 | Blue African Crocidolite asbestos bonded with an acid-resisting binder | 1/16" and 1/8" |
| Flange service against most acids, where a relatively hard, dense gasket is required | 84 | Blue African Crocidolite asbestos bonded with an acid-resisting binder; tough and dense | 1/32", 1/16" and 1/8" |
| Hot and cold water, air and medium or low pressure saturated steam | 107 | Made from a heat-resisting rubber compound; soft and pliable | 1/32" to 1/4" |

Whether its service is usual or unusual, the equipment you design can have tight, long-lasting joints. Because Johns-Manville offers you a choice of many gasket materials...cuts these materials into gaskets made to your individual requirements.

Choose your gasket material from the recommendations listed here...or consult Johns-Manville regarding a special material if your problem is unusual. Your designs will be followed with precision, for Johns-Manville cuts gaskets with the high dimensional uniformity that speeds product assembly.

Consult a Johns-Manville Packing Engineer or ask for the booklet, "Packings for the Product Designer." Johns-Manville, Box 290, New York 16, New York.

JOHNS-MANVILLE JM PRODUCTS

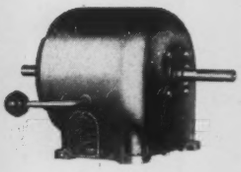
**Johns-Manville** **PACKINGS & GASKETS**

unit accomplishes this close control without the use of cams, motors, bearings, shafts, or gears. Instrument is housed in cast aluminum case 8¼ inches high 6¼ inches wide and 3 inches deep.

## Mold Alloy

MOLDALOY, new alloy for making molds, is now available from Trethaway Associates, 37 Wall St., New York. The new material is recommended for molds for casting low-temperature fusing plastics, rubber molds, wax molds for precision casting processes, etc. It melts at 430 F, has a hardness of 22 brinell, compression strength of 8000 psi, tensile strength of 11,500 psi and a shrinkage of approximately 0.001 inch per inch.

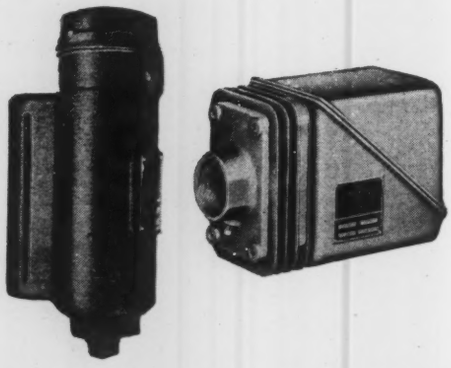
## Gearshift Drive



ADDED to the line of selective-speed gearshift drives manufactured by the Lima Electric Motor Co., Lima, Ohio, is the new Type RD designed to motorize machinery requiring selective speeds in the range ½ to 1 hp. Gear ratios of the new drive are: 1 to 1, 1.33 to 1, 2 to 1 and 4 to 1. Ratios are such that speed changes occur in even steps. Type RD transmission is a four-speed unit similar in design to that previously manufactured. Gearshift lever is available in four optional positions. Conveniently located speed-selection chart facilitates selection of output speeds. Unit will operate in either direction of rotation.

## Combustion Safeguard

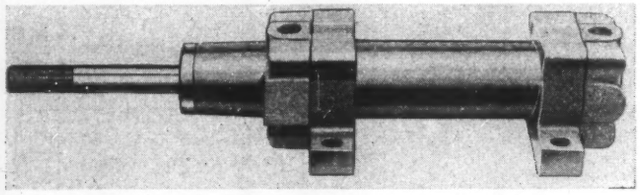
BASED ON a photoelectric tube, a new type of fire-control system for furnaces cuts off fuel or sounds an alarm on flame failure. Unlike thermal controls the new



system, known as Fireye, is not actuated by the effect of flame failure but by the flame itself. Action is said to be positive and instantaneous. The Fireye F18TS unit consists of a phototube and amplifying system housed in a dust-tight aluminum case. Fire control "eye" is mounted direct on furnace wall and is aligned in a manner which permits the photo tube to observe the flame through a 2-inch pipe connection. The device, manufactured by Combustion Control Corp., 77 Broadway, Cambridge 42, combines in a single unit a modern safeguard against the hazards of flame failure and dangerously low boiler-water level. It is designed to protect commercial and industrial oil-burning equipment.

## Hydraulic Cylinders

NOW BEING OFFERED by National Hydraulic Co., Inc., 4505 Oakwood Blvd., Melvindale, Mich., new cylinders have seven standard mountings covering most hydraulic needs. Units are furnished in bore sizes from 1 to 12 inches with virtually any length stroke, and operate



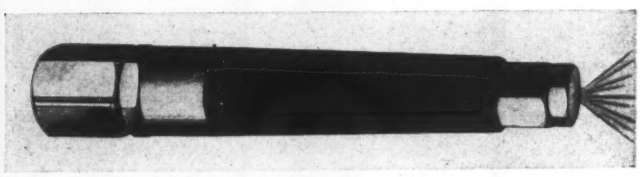
on pressures up to 1500 psi. New construction eliminates tie rods and streamlines the cylinder, making a simplified design. Features include cast Meehanite heads, long bronze side-thrust bearings, special alloy-steel rods, and alloy-steel tubing.

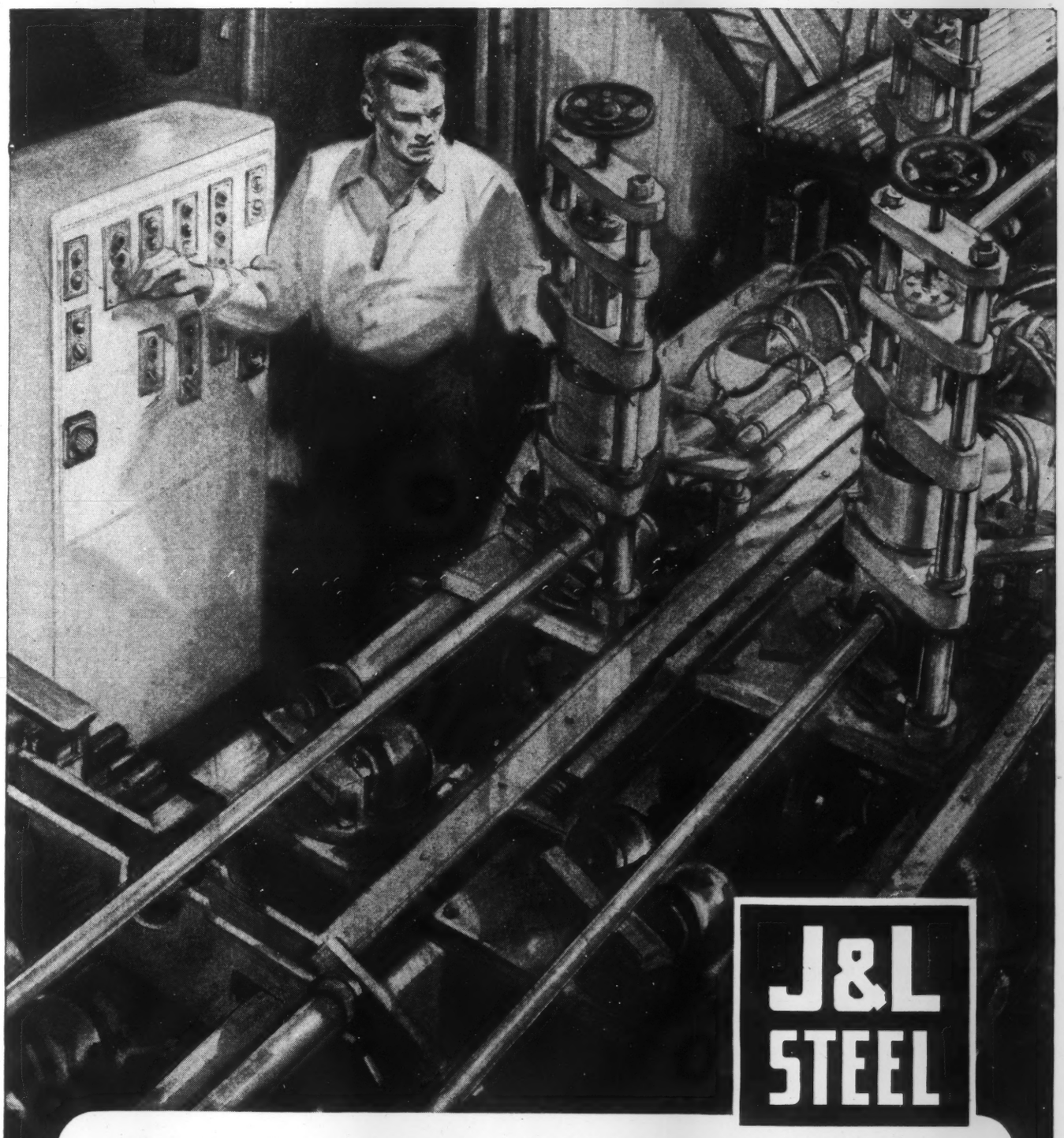
## Insulating Tubing

VARNISH-IMPREGNATED cotton insulation tubing said to be non-cracking is now being manufactured by William Brand & Co., 276 Fourth Ave., New York 10. The tubing, known as Turbotuff, is said to have high dieletric, low moisture absorption and resistance to oils, acids and alkalies. Tubing is available in all standard grades in accordance with ASTM specifications, and in all standard colors.

## Spray Nozzle

LIGHTWEIGHT sensitive spray nozzle known as Finespray, useful for water or other free liquid "atomization," is now being offered by the Lonn Mfg. Co., Inc., East New York St., Indianapolis. The unit is so designed that a slight pressure on the nozzle opens the valve and permits liquid to emerge as spray. When pressure ceases, the spray instantly stops. The nozzle is available with connections for either ¼ or ⅜-inch pipe threads.





J&L STEEL

## *NOW—Even Greater Uniformity with J&L "Electreat" Cold Finished Steel*

You can now gain the additional advantage of increased uniformity in your bar stock by using J&L "Electreat" Cold Finished steel. In this new electric induction heat treatment process each bar is heated and quenched individually in exactly the same length of time as other bars in the lot. This makes possible greater uniformity than is provided by conventionally heat treated bars. In addition, "Electreat" bars retain their sectional accuracy and quality surface. Induction heating also keeps to a minimum decarburization of the bar.

A variety of sizes of "Electreat" Cold Finished bars are available in a wide range of quenched and tempered treatments. Write to address below for full information on how "Electreat" bars can be applied in your operations.

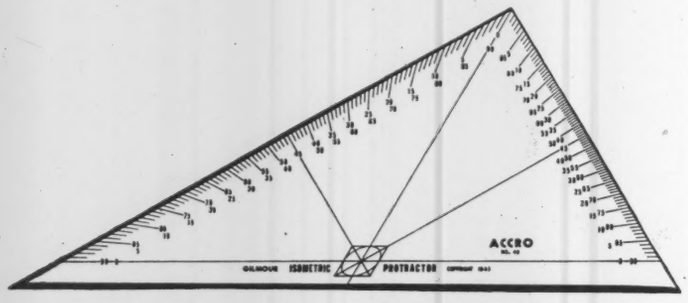
JONES & LAUGHLIN STEEL CORPORATION

PITTSBURGH 30, PA.

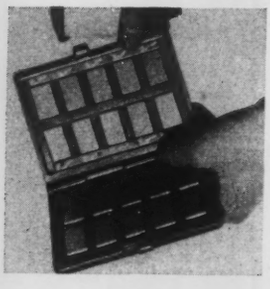
# engineering dept equipment

## Isometric Protractor

DESIGNED for measuring angles in isometric planes, a protractor introduced by Accro Products, 3073 Manhattan Ave., La Crescenta, Calif., is now available. The instrument is numbered along its edges in the manner of a conventional protractor. Numbers, however, do not indicate angles of true size but equivalent angles in the isometric planes. Thus, the protractor is used in the isometric plane in much the same manner as the normal protractor is used in the true plane. The instrument is machined from clear transparent plastic with printing chemically welded to the plastic.




## Machine-Finish Standard



SURFACE-FINISH standard set containing original machine samples, thus insuring accurate comparison, is now being marketed by Edward Blake Co., 634 Commonwealth Ave., Newton Centre, Mass. Set consists of twenty small, stainless-steel, original machine-cut specimens ranging from 2 microinches to 500 microinches rms in surface roughness. Samples are individually positioned in folding case of die-cast aluminum alloy.

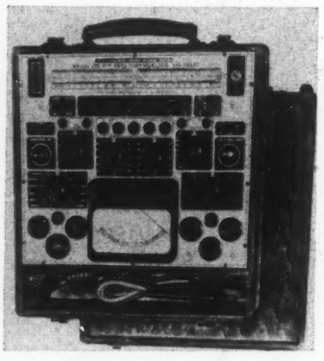
## Microphone

CONDENSER MICROPHONE for measurement of sound pressures now is being offered by the Kellogg Switchboard & Supply Co., 6682 S. Cicero Ave., Chicago. When used with a suitable preamplifier the response of the microphone is about minus 59 decibels referred to one volt per dyne per centimeter squared. Response of the microphone is flat to within one decibel from 100 to 7000 cycles per second and within 3 decibels from 60 to 10,000 cycles per second. The microphone which has an electrostatic capacity of approximately 35 $\mu\mu$f, has been successfully used to measure intensities of 1200 to 1400 dynes per square centimeter.

## Profilometer Tracer

REPLACING earlier Type M tracer, the new Type MA profilometer tracer has been placed on the market by the Physicists Research Co., 321 S. Main St., Ann Arbor, Mich. Operation of the new instrument consists merely of placing it on and moving it along a surface to obtain a microinch reading. Range of the new tracer is similar to that of the type it replaces, and it is self-adjustable to all surfaces within its range.

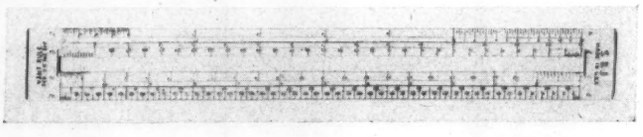
## Tube Tester

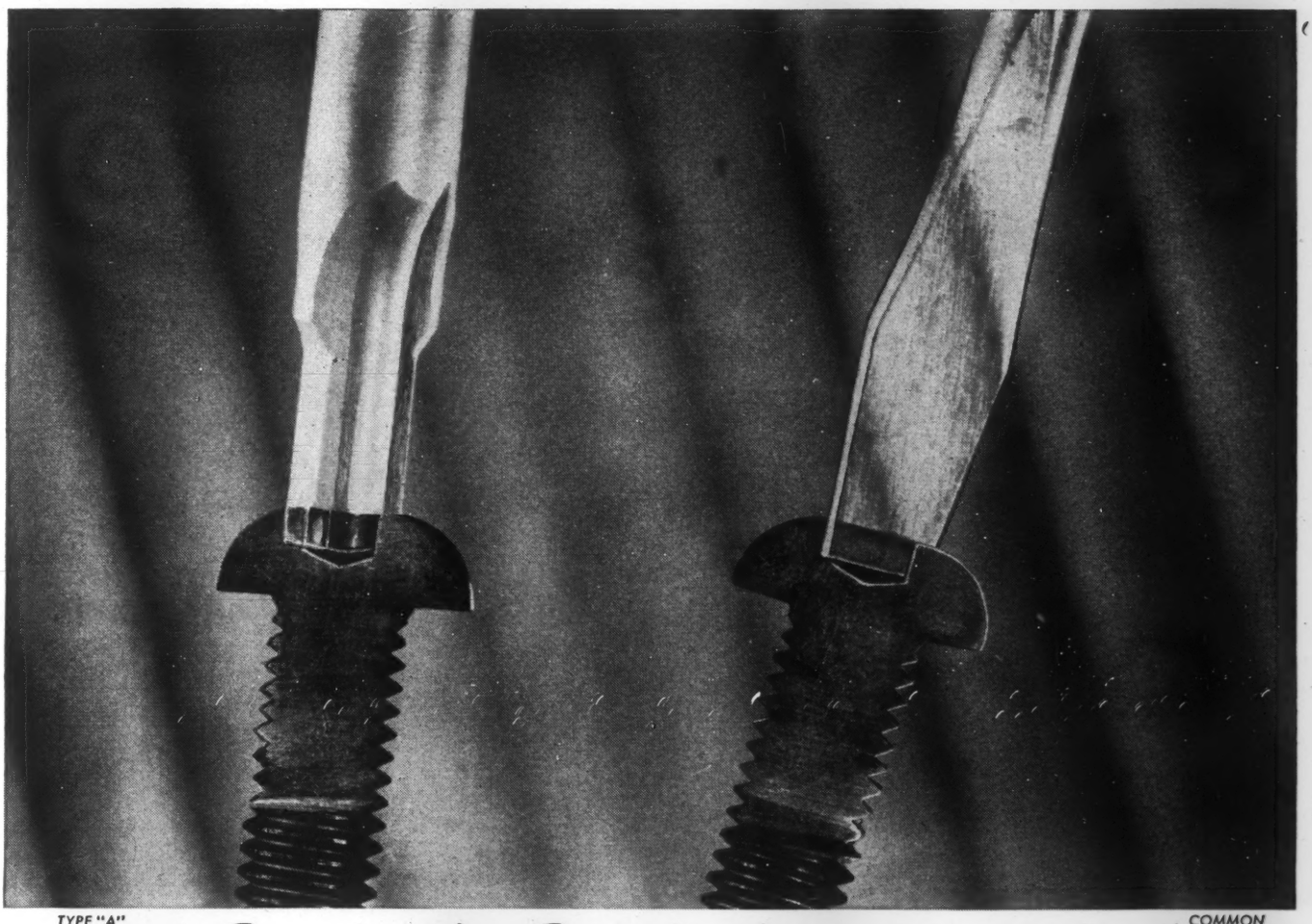


PORTABLE combination tube, battery and radio-set tester is now available from the Precision Apparatus Co., Inc., 92-27 Horace Harding Blvd., Elmhurst, L. I., N. Y. The unit, which is a mutual-conductance instrument, tests all tubes with filament voltages to 120 volts and tests batteries from 1.5 to 135 volts. It features an automatic pushbutton system and free-point terminal selection regardless of rotating pin positions. The instrument, known as 954-P Electronamic Tube, Battery and Set Tester, provides wide-range current scales from 60 microamperes to 12 amperes, resistance to 60 megohms and DB ranges to 70 DB.

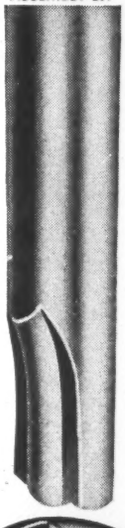
## Drafting Scale

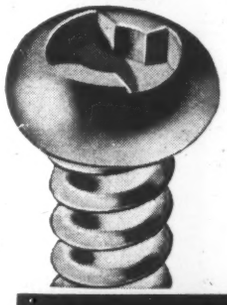
DRAFTING SCALE of crystal clear heavy plastic with calibrations and numerals in red is being offered by the Stewart-Jackson Instrument Co., 215 W. Seventh St., Los Angeles 14. The scale, known as the Vant rule, incorporates eight different scales on one side. Provided are calibrations of ⅛, ¼, ⅜, ½, ¾, 1, 1½ and 3 inches per foot. The instrument measures 13½ inches in length and all edges are beveled.





TYPE "A" ASSEMBLY BIT





COMMON SCREWDRIVER

# *Here's the Quick Answer to* CLUTCH HEAD *Supremacy*

**All "taken apart" for your examination and comparison... the principle of CLUTCH HEAD'S logical construction for safer, smoother, faster, and lower-cost assembly operation.**

Note the Center Pivot column on the assembly bit; how it matches the curvature in the recess for dead-center entry.

This automatically straightens the driving action; checks out driver canting for "chewed-up" heads and slippage.

Look through the "phantom" bit. You see straight sides of the driver matching straight walls of the clutch recess.

Hence CLUTCH HEAD's non-tapered drive . . . with no ride-out to kick the driver into damaging skids.

Add to that the smoother, easier driving action with this all-square contact . . no ride-out, therefore no call for exhausting end pressure.

To the right, you see how CLUTCH HEAD is basically designed for common screwdriver operation. The torque grip is definite on two broad deep-down pressure areas for quick and easy field adjustment without damage to screw.

*We invite you to make your own test on these and the several other exclusive* CLUTCH HEAD *features. Send for screw assortment and sample Type "A" Bit. Check the Lock-On that unites screw and bit as a unit for one-handed reaching; figure the tool economy of the Type "A" Bit ...and what screwdriver control means to simplified servicing of your product in the field.*

CLUTCH HEAD SCREWS

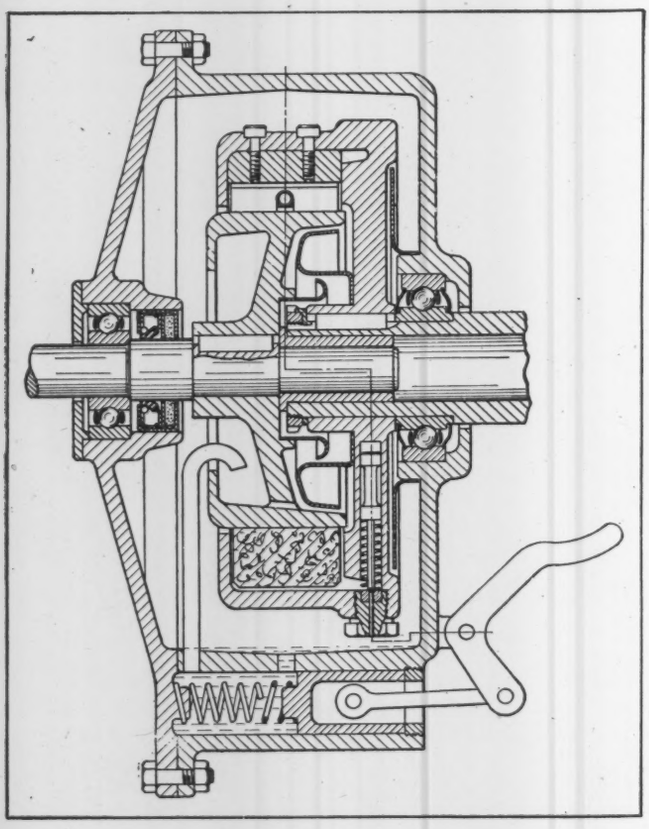
**UNITED SCREW AND BOLT CORPORATION**

CLEVELAND 2 CHICAGO 8 NEW YORK 7

# Noteworthy Patents

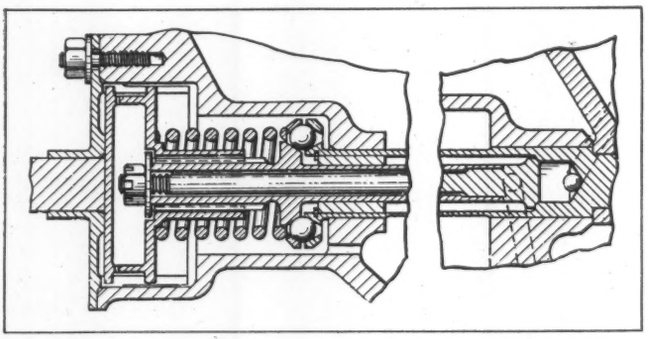
**MAGNETIC FORCE** is utilized to actuate a safety linkage for a new design of textile twister covered in patent 2,411,126 assigned to Saco-Lowell Shops by V. A. Burnham. By using mutually attracted magnets, the yarn package carrier is held stationary with the housing. Should trouble develop, however, the carrier revolves, the magnets again acting to repel a pivoted magnetic arm on the housing which in turn both disconnects the motor and applies a brake to the spindle.

**CENTRIFUGAL CLUTCHING** by means of liquid mercury which can be automatically engaged or disengaged during operation is outlined in patent 2,412,378 assigned to Mercury Clutch Corp. by H. J. Zimmermann. A spring-loaded valve is provided for releasing the actuating mercury to a reservoir when clutch speed is reduced to a predetermined point. Conversely, when speed exceeds this figure the valve closes and when the mercury is returned to the inner clutch member, drive is again established. Various modifications of the design make possible either manual or automatic return of the mercury and, in addition, engagement at any desired speed above the preset minimum. When conditions so require, all functions can be made manually to provide complete control over speed range.



**LIQUID-COOLED PISTONS** are employed in a free-piston engine and compressor design covered in patent 2,411,886, assigned to United Aircraft Corp. by W. A. Ledwith. Coolant is pumped from a hollow rack tube attached to the air compressing portion of the piston assembly and flows into the interior of the hollow piston shell through a series of passages to a central duct and thence around the engine-piston walls. Fluid is discharged from the piston into a similar opposite hollow rack to the sump.

**PREDETERMINED CONTROL** movement as well as guarantee against intermediate positioning by an operator is provided by a novel control mechanism covered in patent 2,410,631. Assigned to Wright Aeronautical Corp. by Ronald Chilton and Donald G. MacCulloch, the control is



intended primarily for use in valving oil to fluid coupling devices to control automatic speed shifting in a multispeed transmission. Through the use of both cam and ball-and-socket action, rotative force applied to the control shaft connection creates a snap action which insures an exact, predetermined opening of the valve without dwell.

Wherever extraordinary or difficult operating conditions prevail, Sirvene pliable parts deliver dependable service at the very heart of the mechanism. They may control fuel intake, maintain delicate air pressure and fluid ratios, or provide an effective seal against mud, dirt, oil, water and other solubles. In each application Chicago Rawhide engineers custom-develop the Sirvene part from special formulae so that it meets exact specifications in design, elasticity or hardness, resilience, compression set, temperature resistance and tensile strength. Whenever your designs require unusual molded parts, investigate Sirvene first.

# SIRVENE

THE *SCIENTIFIC* COMPOUNDED ELASTOMER

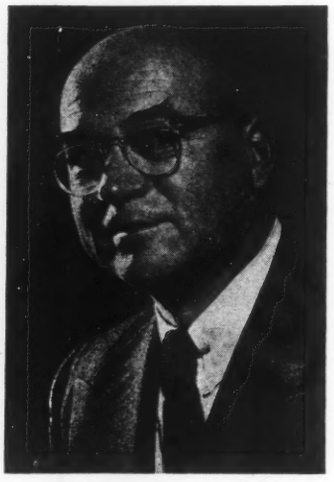
*A Product of the Synthetic Rubber Division*

1305 Elston Avenue · Chicago 22, Illinois

***Sirvene products include diaphragms, boots, gaskets, oil seals, washers, packings, and other special molded mechanical pliables.***

*William H. Myers*

*Carl A. Lindblom*



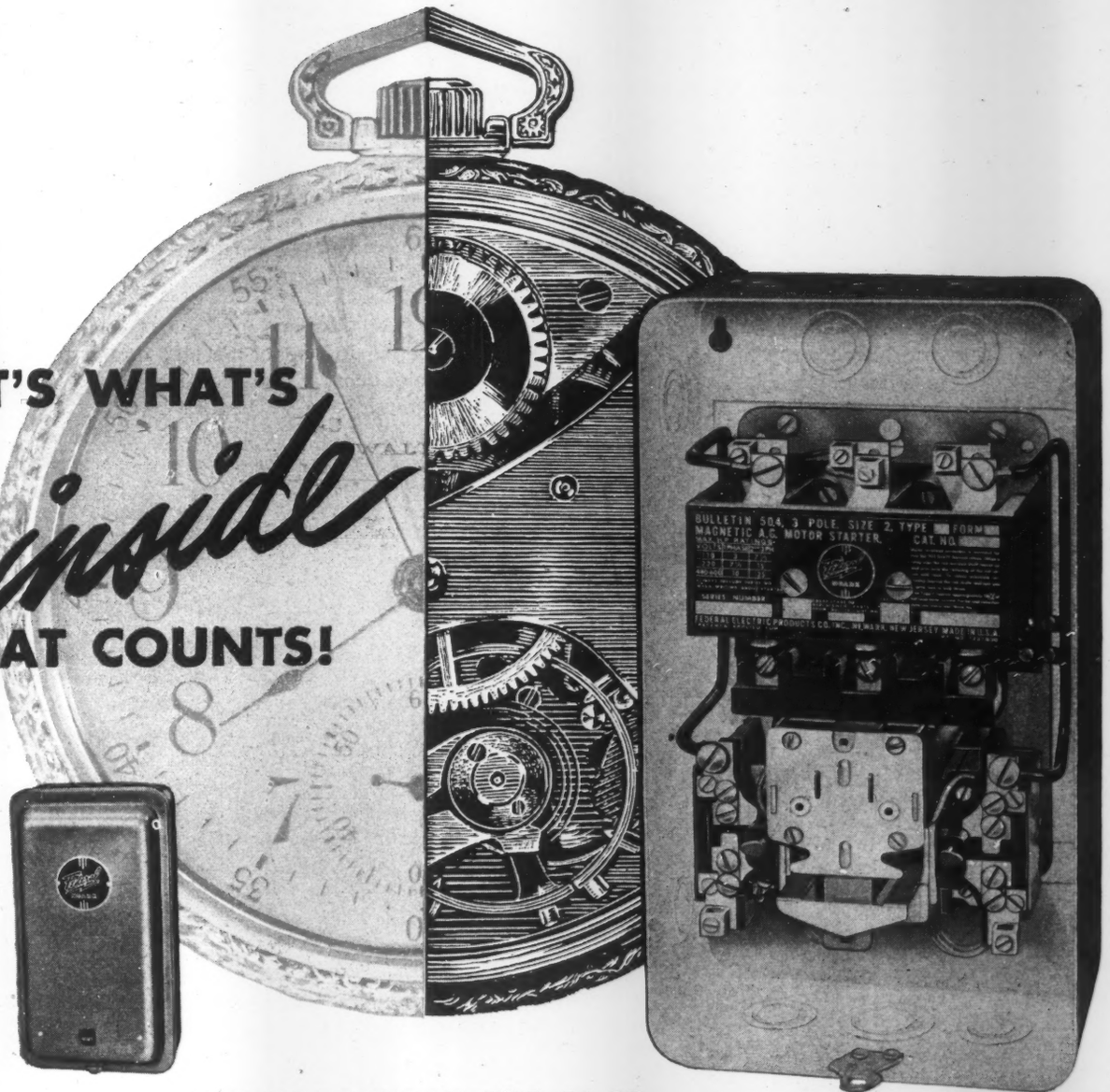
*Thomas L. Hibbard*

# MEN...of...machines

WILLIAM H. MYERS, who since the war has been product engineer in charge of automobile radios, has been made chief engineer of the receiver division, Farnsworth Television & Radio Corp. During the war Mr. Myers was project engineer in charge of the company's aircraft and tank radio transmitters, as well as its important electronic bombsight project for the Armed Forces. Mr. Myers has been connected with the Farnsworth company since January, 1940 when he joined the organization as sales engineer. Prior to that time, he had been associated for eleven years with the engineering department of the Crosley Corp. Before joining Crosley Corp. he had been with the Automobile Radio Corp. and the Packard Motor Car Co. Well known in automobile radio development, Mr. Myers was responsible for numerous improvements and new devices in that field.

CARL A. LINDBLOM, well known automotive engineer, has been appointed chief engineer of the White Motor Co. Prior to accepting this position, Mr. Lindblom had been chief engineer of Volvo, largest manufacturer of passenger cars and trucks in Sweden. A native of Michigan, he attended Wayne university and the University of Michigan. From 1926 to 1938 he served as assistant chief of the automotive design section of General Motors Research Laboratories. He left to become assistant chief engineer of the passenger car division of Volvo, where he remained for two years. At this time he returned to Detroit as consulting engineer and buyer for the Volvo organization. From June, 1942 to December, 1945 he was chief of the Armored Car Section, Office of the Chief of Ordnance in Detroit, and spent seven months overseas in 1945 for the United States Ordnance Department and the C.I.O.S. Technical Commission. Following his wartime service in the Ordnance Department, he again returned to Sweden to become chief engineer for Volvo, from which position he recently resigned to join The White Motor Co.

THOMAS L. HIBBARD, new director of styling for the Ford Motor Co., has been active as an automobile designer since early boyhood. While attending high school in Cleveland he was employed by Rubay Co., custom body builders, as a designer of special bodies for Packard, White, Locomobile and other quality cars of the period. Before




# IT'S WHAT'S *inside* THAT COUNTS!

HIDDEN BEHIND THE FACE of your watch are over 150 precision parts—the "works" that make a watch a useful and dependable mechanism. In FEDERAL NOARK electric products, as in the construction of a fine time-piece, *precision* is a built-in characteristic . . . precision that makes for dependable performance under the most gruelling of operating conditions.

**HERE'S THE "WORKS" OF A FEDERAL NOARK MAGNETIC MOTOR STARTER**

• Double Break Silver Contacts • Accessible Stationary Contacts • Single Screw Movable Contacts • Heavy Arc Barriers for Strength • Ball Bearings & Movable Yoke • Non-Carbonizing Asbestos Base • Vertical Ball Bearing Action • Quick-Change Coils • Overload Relays — Hand & Automatic Reset • Front Mounted Accessible Heaters

Federal Electric Products Company, Executive Offices: 50 Paris Street, Newark 5, N. J. • Plants: Hartford, Conn. • Newark, N. J. • St. Louis, Mo.

# Federal NOARK
## INDUSTRIAL CONTROLS

FEDERAL ELECTRIC PRODUCTS COMPANY, MANUFACTURERS OF A COMPLETE LINE OF ELECTRICAL PRODUCTS INCLUDING: MOTOR CONTROLS, SAFETY SWITCHES, CIRCUIT BREAKERS, SERVICE EQUIPMENT, PANELBOARDS

he was twenty he served as chief designer for the C. P. Kimball Co., custom body builders. His fame as a custom designer rose sharply in 1920 when, assisted by Raymond Dietrich and Ralph S. Roberts, he organized LeBaron Inc. Disposing of this interest, he organized the firm of Hibbard & Darrin, custom car designers, with offices in Paris. The firm constructed its own body plant for the production of cast aluminum bodies and during the twenties built hundreds of custom car bodies. Mr. Hibbard then joined Cadillac as chief stylist and later (in 1940) the Ford company as special project engineer where he was responsible for the development of a large armored car, a six-wheeled vehicle known as the GQ Model. This was predecessor of the famed M-8 light armored car used during the war.

♦

HOWARD F. DOLL has recently been made vice president in charge of engineering for the Victor Electric Products Inc., Cincinnati. He had been chief engineer.

♦

J. H. DAVIDS has been promoted from design engineer of the Fairbanks, Morse & Co., Beloit, Wis. plant to assistant chief engineer of the Diesel Engine Division of the company.

♦

PAUL H. MAURER is the new chief engineer of National Pneumatic Co., Rahway, N. J., and is responsible for all production engineering, research and development.

♦

O. E. EGGEN, previously director of engineering in the Chicago office of Oliver Corp., is now plant manager of the Cleveland office.

♦

WILLIAM S. JAMES, formerly associated with Studebaker for 18 years as research engineer and later as chief engineer, has been placed in charge of the research department, engineering division, Ford Motor Co. E. T. GREGORIE will head the styling department. DALE ROEDER, connected with Ford since 1925, is chief engineer of the commercial vehicle department which includes trucks, buses and tractors. He has been chief of commercial vehicle design since 1929. The passenger car engineering will be headed by H. H. GILBERT and H. S. CURRIER. L. L. BELTZ will head the electrical engineering department, while ALBERT W. FREHSE will head the department responsible for testing. E. C. MCRAE is in charge of the engineering division's patent and vehicle department.

♦

FAYETTE LEISTER, who has been engineering manager at Fafnir Bearing Co., recently has been appointed vice president in charge of engineering. Mr. Leister holds numerous patents covering improvements in antifriction bearings.

♦

E. W. CHAPMAN, previously chief engineer of Blackmer Pump Co., has been made chief engineer of the newly created Industrial Pump Division of Bowser Inc., with headquarters in Fort Wayne, Ind. J. C. LUNGERHAUSE, a specialist in the design of positive displacement pumps, has also joined this division in the capacity of chief development engineer.

♦

D. G. CAMERON, chief engineer of Penn Electric Switch Co. for two years, has been promoted to vice president in charge of manufacturing. He will co-ordinate functions of manufacturing, engineering, production and plant engineering. FRED W. HOTTENROTH, who replaces Mr. Cameron as chief engineer, has been assistant chief engineer. He will be responsible for engineering design, drafting, laboratory, model shop and specifications department.

♦

D. E. BATESOLE, vice president and chief engineer, Norma-Hoffman Bearings Corp. has been appointed chairman of the ball and roller bearings committee of the SAE Technical Board.

♦

J. N. GOODIER, professor of machine design and head of the department of machine design and the department of mechanics at Cornell university, is the first winner of the Westinghouse Award for Notable Contributions in Engineering Teaching offered by the Society for the Promotion of Engineering Education.

---

# Cyclic Variations in Speed

(*Concluded from Page* 111)

applications. When $d$ becomes greater than unity there is a reversal in velocity of the driven member at the point of minimum velocity.

In some applications it may be necessary to know the value for the angle $A$ at the instant when the velocity of the driven member is exactly the same as that of the driver. From the velocity equations for both types this condition exists when $\cos KA = N$.

It is advisable to check the maximum angular acceleration and from the inertia characteristics of the driven mass determine the maximum torque requirements. From the kinematics of the mechanism it will then be possible to calculate the loads and properly design the slide block, crank, crankshaft, gears, and input shaft.

Advantages of cycloidal cranks may be summarized as follows:

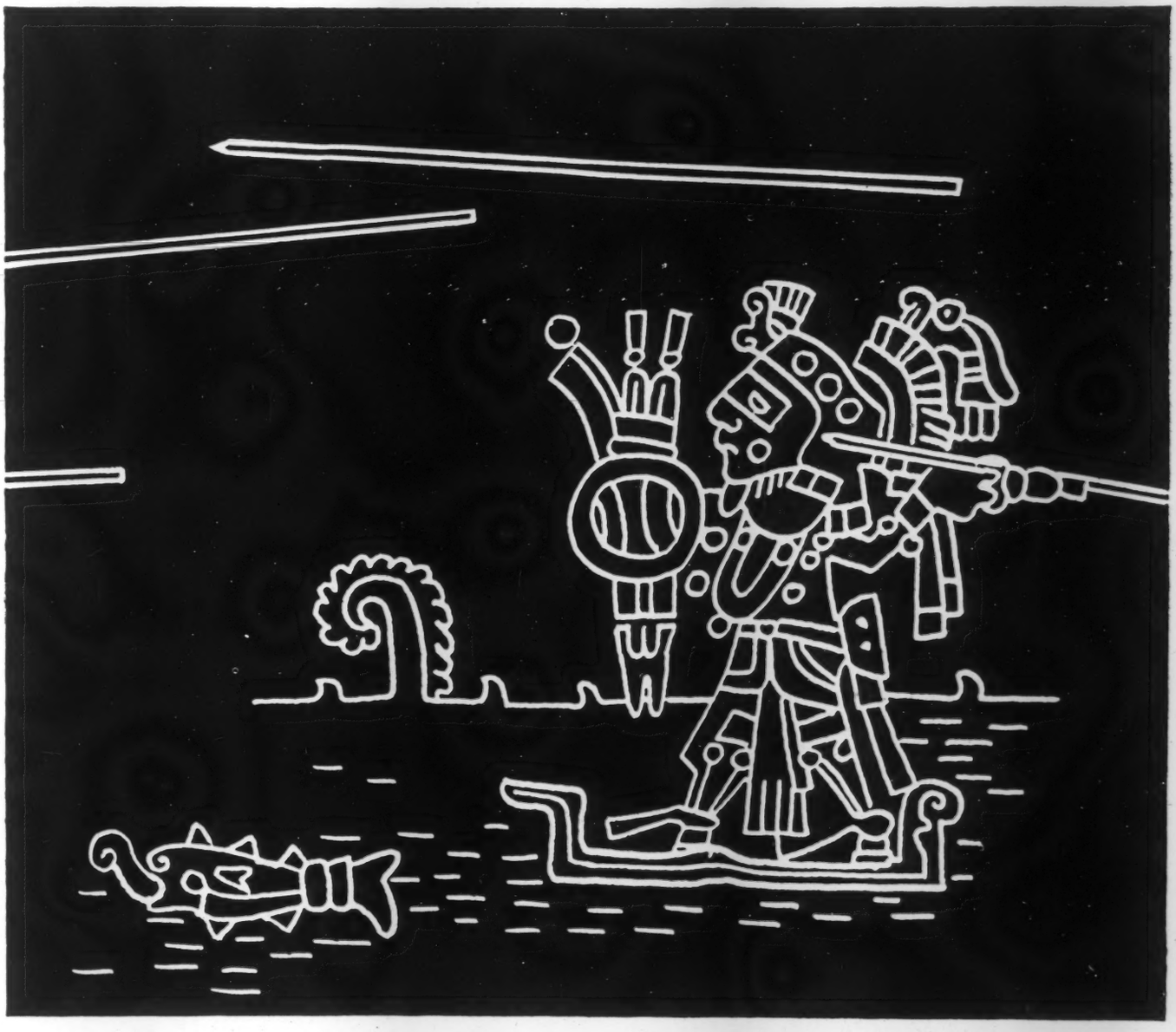
1. Wide variation obtainable in maximum and minimum velocity, including reversal of driven member if desired. This latter condition exists when the crank radius is greater than the planet gear radius
2. It is possible to cause cyclic variation a number of times per revolution by the use of the proper gear ratio
3. Driven and drive shafts are in line
4. Standard gears can be used
5. All component parts can be manufactured on standard machine shop equipment.

Only two types of cycloidal cranks in which the driven member has a variable rotary motion have been discussed in this article. There are many other types of mechanisms possible employing cycloidal cranks. There is the possibility of using only the vertical or horizontal component of the crank locus to reciprocate a scotch yoke type of slide or in combination with a connecting rod and crosshead. The many combinations of gear ratio, crank length, and driven member make available a wide choice of mechanisms which are both interesting to design and practical to use.

# HOW TO MAKE AN ARM GROW

A human arm can throw a spear only so far. But some ancient genius of an engineer figured out that, by employing a throwing stick, which the Aztecs called *atlatl,* the lever of the human arm —and the distance achieved—could be extended, with quite pointed results for an enemy.

Specifying molybdenum in steel is something like using an *atlatl.* For molybdenum extends the usefulness of good steel. By providing good hardenability at low cost, molybdenum steels permit modern engineers to save weight—and costs—in design. It pays to specify molybdenum.



MOLYBDIC OXIDE—BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"
CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

**Climax Molybdenum Company**
**500 Fifth Avenue · New York City**

MOLY

# Design Abstracts

## Specifying Surface Finish

IF AN old-time machinist were asked to make a hydraulic piston and rod assembly he would undoubtedly finish it smooth all over. He would take pride in its appearance and he would not consider a rough surface or a chatter mark acceptable shop practice. He might spend an hour turning and polishing the flat piston faces and an equal time on the rod itself.

It is seldom good economy to make a surface smoother than it really needs to be, unless it can be finished at the same time as an adjacent surface or unless the only means of sizing will actually produce a smooth surface. The adoption of a proper drawing notation which will point out those surfaces of a part which need special care and a fine finish, as well as those which can be allowed to remain rough, will reduce costs by preventing misapplication of effort. The designer is best able to determine these facts at the time the drawing is made.

In the example the rod itself must slide through a packing gland and must therefore be smooth. The outside diameter of the piston must also be smooth since it slides along the inside of the hydraulic cylinder, but it need not be as smooth as the rod since it is always well lubricated and slides against a smooth metal cylinder bore. The rod however must slide against a soft packing and may be dry and dusty when retracted. The only other surfaces of importance are the packing ring groove in the piston head and the mating surfaces that attach to the machine driven by the strut. The two flat faces of the piston, therefore, can be as rough as normal rapid machining processes will leave them.

It would therefore be advisable to inform the machinist and inspector of these facts by designating the required surface quality for each surface of the part by indicating roughness values on the drawing. Such roughness numbers indicate the maximum allowable average surface roughness in microinches as indicated by either an instrument or by fingernail comparison with standard roughness having known roughness values.

From these notations the machinist will know at once that the piston rod must be very smooth, the ring groove not quite as smooth, the piston diameter just smooth but the flat ends of the piston can be rough. He will therefore put the time into the surfaces that need special care and let the rest go. Of course they must still be held to proper dimensional tolerances. His boss will not question his work when the drawing clearly indicates that some surfaces can be rough.

There are many parts far more complicated than a piston rod where it would be almost impossible for anyone but the designer to know which surfaces are critical and which are not. If the designer designates the required finish for the critical surfaces and gives a generous overall roughness allowable for the noncritical ones, savings will accrue all along the line, or for equal cost more perfect critical surfaces can be prepared which will improve quality and life.

Among the qualities that are affected by changes in surface roughness might be included:

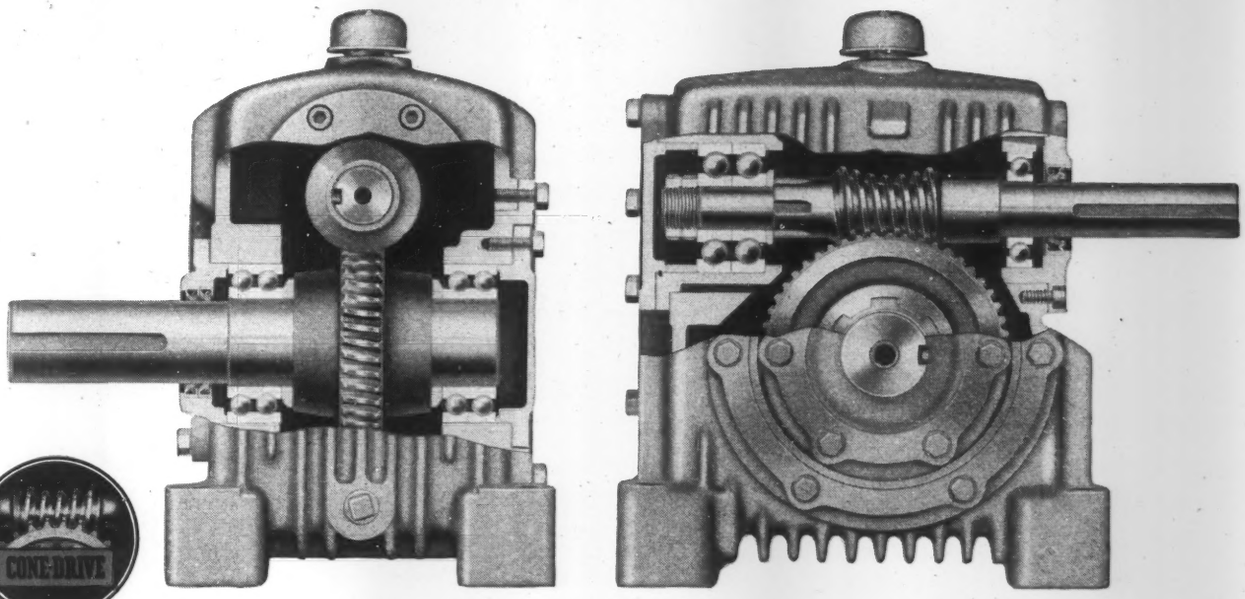
1. Life—how long will it last?—Remember friction, abrasion, wear, lubrication, bearing area, corrosion and galling
2. Safety—how strong is it?—Remember stress concentrations, fatigue strength, notch sensitivity and imposed loads
3. Function—will it work properly? — Must it slide freely, fit properly, prevent leakage, serve as a bearing, as a mating part or rub over packings without damaging them?
4. Appearance—does it look good?—How about adhesion of plating or other protective coatings such as paint? (Are good looks important?)
5. Heat transmission—Rough surfaces are good radiators and heat absorbers, smooth surfaces serve better as insulators
6. Are optical properties important? — Mirrors and lenses; how about transmission, reflection, refraction of light or heat?

*— From a paper by James A. Broadston, chief engineer, Surface Checking Gage Co., presented at a meeting of the Instrument Society of America in Pittsburgh.*

## Transport Aircraft Engine Design

UNTIL comparatively recently, the liquid-cooled engine has been little used in transport aircraft, either civil or military. Although the civil transport routes of the world have been operated almost entirely with air-cooled engines, the liquid-cooled engine is making a strong bid for a front-rank place in this field, using four-engined military aircraft merely converted for transport work or partly redesigned. Some 25 million miles have been covered by these planes during the past two years.

Use of liquid cooling enables high powers to be obtained from a relatively small, compact engine, and it follows that such an engine will operate at relatively high piston speeds and mean effective pressures, compared with current air-cooled engine practice. There are some who claim that there is a general correlation (irrespective of engine type) between mechanical reliability and MEP or piston speed, or both. Actually, no such general claim has ever been substantiated, and it is not likely to be. Any type of engine can be made to give the full power rating of which it is inherently capable with any required degree of mechanical reliability, provided that it is designed and developed with sufficient intelligence and ingenuity.— *From a paper by J. D. Pearson and E. Warlow-Davies, Rolls-Royce Ltd., presented at the recent SAE national air transport engineering meeting.*



# *There is more beef than meets the eye* in STANDARD CONE-DRIVE SPEED REDUCERS

Check this table of ratings of Standard Cone-Drive Reducers against any other make. There is beef in the compact housings too—plus plenty of cooling area. The model HO-7400 illustrated here is a 4-inch C. D. unit, ideal for conveyor drive or other materials handling applications. Note the double row ball bearings—the rigidity of the housing design.

You can't go wrong on Cone-Drive reducers. They give you greater ruggedness, increased load capacity, smaller size, high thermal efficiency, long trouble-free life. Made in pinion-under and pinion-over, gearshaft vertical or horizontal models. Available with water-cooling and extended shafts.

Write for Bulletin, giving approximate horsepower or torque and ratio required.

**CONE-DRIVE DIVISION**
**MICHIGAN TOOL COMPANY**
**7171 E. McNichols Road, Detroit 12, U. S. A.**

## HORSEPOWER RATINGS AT 100 & 1750 PINION RPM

| 2 inch Center Distance | | 3 inch Center Distance | | 4 inch Center Distance | | 5 inch Center Distance | | 6 inch Center Distance | | RATIO | 8 inch Center Distance | | 10 inch Center Distance | | 12 inch Center Distance | | 15 inch Center Distance | | 18 inch Center Distance | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 1750 | 100 | 1750 | 100 | 1750 | 100 | 1750 | 100 | 1750 | | 100 | 1750 | 100 | 1750 | 100 | 1750 | 100 | 1750 | 100 | 1750 |
| .35 | 2.96 | 1.24 | 9.04 | 3.00 | 19.8 | 6.07 | 37.0 | 10.4 | 59.1 | 5:1 | 24.4 | 119.2 | 45.8 | 208. | 77.6 | 336. | | | | |
| .21 | 1.95 | .75 | 6.11 | 1.81 | 13.4 | 3.65 | 24.47 | 6.35 | 40.4 | 10:1 | 14.7 | 82.6 | 28.0 | 145. | 47.1 | 217. | 86.0 | 410. | 133. | 632. |
| .15 | 1.40 | .53 | 4.39 | 1.27 | 9.64 | 2.58 | 18.09 | 4.46 | 29.1 | 15:1 | 10.4 | 61.2 | 19.8 | 105. | 33.8 | 163. | 60.5 | 299. | 91. | 446. |
| .11 | 1.10 | .40 | 3.40 | .98 | 7.5 | 2.00 | 13.96 | 3.39 | 22.5 | 20:1 | 7.92 | 46.9 | 15.2 | 81.6 | 26.6 | 131. | 45.3 | 232. | 69. | 361. |
| .09 | .86 | .33 | 2.77 | .79 | 6.03 | 1.60 | 11.2 | 2.77 | 18.4 | 25:1 | 6.47 | 38.4 | 12.3 | 66.9 | 21.4 | 106. | 36.6 | 189. | 55.5 | 296. |
| .08 | .73 | .27 | 2.32 | .65 | 5.06 | 1.34 | 9.47 | 2.32 | 15.8 | 30:1 | 5.42 | 32.2 | 10.2 | 56.0 | 17.9 | 89.0 | 30.0 | 161. | 46.2 | 248. |
| .06 | .55 | .21 | 1.75 | .50 | 3.79 | 1.01 | 7.13 | 1.75 | 11.8 | 40:1 | 4.1 | 24.4 | 7.77 | 42.4 | 13.6 | 67.2 | 22.2 | 122. | 34.2 | 186. |
| | | .17 | 1.40 | .39 | 3.07 | .809 | 5.70 | 1.40 | 9.45 | 50:1 | 3.28 | 19.5 | 6.22 | 33.9 | 10.9 | 53.8 | 18.0 | 95.8 | 27.6 | 150. |
| | | | | .33 | 2.54 | .675 | 4.75 | 1.17 | 7.87 | 60:1 | 2.74 | 16.2 | 5.20 | 28.7 | 9.00 | 45.5 | 12.7 | 80.6 | 21.5 | 125. |
| | | | | | | .58 | 4.08 | 1.00 | 6.75 | 70:1 | 2.34 | 13.9 | 4.45 | 24.6 | 7.72 | 39.0 | | | | |

Ratings apply to both Standard Cone-Drive Speed Reducers and Standard Cone-Drive Gear Sets.

# Rotating Disks

(*Continued from Page* 137)

any trial solution can be made to satisfy the disk if the external load is arbitrarily increased or decreased at the outside diameter until Equation 29 is satisfied. In other words, every trial solution is the solution of the disk for a given external loading. Now the tangential stress at the inside diameter of the disk can be expressed as a function of the radial stress at the outside diameter as follows:

$$\sigma_{ti}=B+C\sigma_{ro} \quad \ldots\ldots (35)$$

where $C$ is a constant and $B$ = value of $\sigma_{ti}$ when $\sigma_{ro}$ equals zero.

Letting $\sigma_{ro}'$ be the final radial stress when $\sigma_{ti}'$ is the initial tangential stress, and $\sigma_{ro}''$ the value corresponding to an initial stress, $\sigma_{ti}''$, then

$$C=\frac{\sigma_{ti}''-\sigma_{ti}'}{\sigma_{ro}''-\sigma_{ro}'} \quad \ldots\ldots (36)$$

Two trial solutions give enough data to solve for $C$ and $B$. Then by substituting the actual value for $\sigma_{ro}$ in Equation 35 the correct value of $\sigma_{ti}$ can be solved. In many cases $\sigma_{ti}$ is the maximum stress in the disk, but if additional information is desired this value of $\sigma_{ti}$ may be used for a third and final $S$ and $D$ solution, giving a check and also enabling plotting of values of $\sigma_t$ and $\sigma_r$ against values of radius. An alternate method of investigating the stresses at any other point in the disk can be established by using the counterpart of Equations 35 and 36 with the stress in question substituted for $\sigma_{ti}$.

### Construction of Sum and Difference Chart

When constructing a sum and difference chart, it is a good idea to draw the chart on a durable sheet of tracing cloth. Values of $S$ and $D$ should be laid out to a suitable scale so that they can be scaled off during the graphical solution of disks. By assigning various values to $C_1$ in Equation 26 a series of equally spaced $S$ curves can be obtained. It is necessary to plot only one of these curves. Then on several velocity lines ordinates for the other $S$ curves can be laid out at equal intervals from the initial curve.

For laying out the $D$ curves Equation 27 may be rewritten as follows:

$$D=\frac{36}{386}(1-\mu)\gamma u^2+\frac{K}{u^2} \quad \ldots\ldots (37)$$

When $K$ is equal to zero, an initial $D$ curve passes through zero on the chart. All of the other $D$ curves can be laid out from this initial curve by assigning various values to $K$. However, it is not necessary to tabulate values for the various $D$ curves. For example, if at a given velocity the ordinates of the various $D$ curves were equally spaced at a distance, $H$, then:

$$\frac{K_2}{u^2}-\frac{K_1}{u^2}=H$$

$$K_2-K_1=Hu^2=K'=\text{a constant}$$

where $K_1$ and $K_2$ are values assigned to $K$ in Equation 37. Solving

$$H=\frac{K'}{u^2} \text{ or } u^2=\frac{K'}{H}$$

By assigning a value to $K'$ and tabulating $u^2$ and $u$ for various values of $H$ a series of equally spaced points lie on the corresponding velocity lines. These will give a family of $D$ curves which will partially fill the chart. For the lower part of the chart, additional values will have to be assigned to $K'$ until the chart is entirely filled with $D$ curves.

### Averages Stress In Disk

When a rotating disk is split along a diameter and half of the disk is considered as a free body, then an external tangential force will be required to balance the centrifugal forces on the half disk. If this tangential force equals $T$, $A$ equals the area of the half section of the disk, and $\sigma_{tm}$ equals the average stress in the disk, then

$$\frac{T}{2}=\sigma_{tm}A=\int_{ri}^{ro}\sigma_t dA \quad \ldots\ldots (38)$$

Considering the disk to be made up of a number of separate thin rings of thickness $dr$, the centrifugal forces on any of these rings can be found by replacing $t$ with $dr$ in Equation 3. This gives the following:

$$df=\rho b\omega^2 r dr$$

If $dZ$ equals the external loading on the ring in pounds per inch of periphery, then the bursting force on the ring will be

$$P=2r(df+dZ)$$

Now if $F$ equals the total external load on the disk and $dF$ the total external load on the ring, then $dZ = dF/2\pi r$ and

$$P=2\rho b\omega^2 r^2 dr+\frac{dF}{\pi}$$

Therefore,

$$\frac{T}{2}=\int_{ri}^{ro}\frac{P}{2}dr=\rho\omega^2\int_{ri}^{ro}r^2 b dr+\int_{ri}^{ro}\frac{dF}{2\pi}$$

$$=\rho\omega^2\int_{ri}^{ro}r^2 dA+\frac{F}{2\pi}$$

In the foregoing equation, the expression $\int r^2\,dA$ is equal to the moment of inertia of the area of the half section. Substituting the symbol $I$ for this quantity and solving for $\sigma_{tm}$,

$$\sigma_{tm}=\frac{T}{2A}=\rho\omega^2\frac{I}{A}+\frac{F}{2\pi A}=\frac{\gamma}{386}\omega^2\frac{I}{A}-\frac{F}{2\pi A} \quad \ldots\ldots (39)$$

Experience may prove that, for a given type of disk, values of tangential stress will closely follow the equation:

$$\sigma_t=\frac{K}{r^n} \quad \ldots\ldots (40)$$

where $K$ = a constant of the disk as loaded and $n$ = an

# Welded Design Cuts Machine's Cost 60%

BY H. H. STAHL, DISTRICT MANAGER AND WELDING ENGINEER, THE LINCOLN ELECTRIC CO., BOSTON, MASS.

A striking example of a present-day trend in machine design is the evolution of a strawboard shear machine made by Hobbs Manufacturing Co., Worcester, Mass.

Redesign of this machine for fabrication by electric arc welding resulted in a machine with a weight of only one-third that of the original and costing 60% less to produce.

In the former design (see Fig. 1), the various parts of the shear were made in individual pieces and had to be hand-fitted, drilled and bolted. All of these operations were eliminated by the welded design (see Fig. 2), which utilizes rolled steel in standard angles and plate sizes.

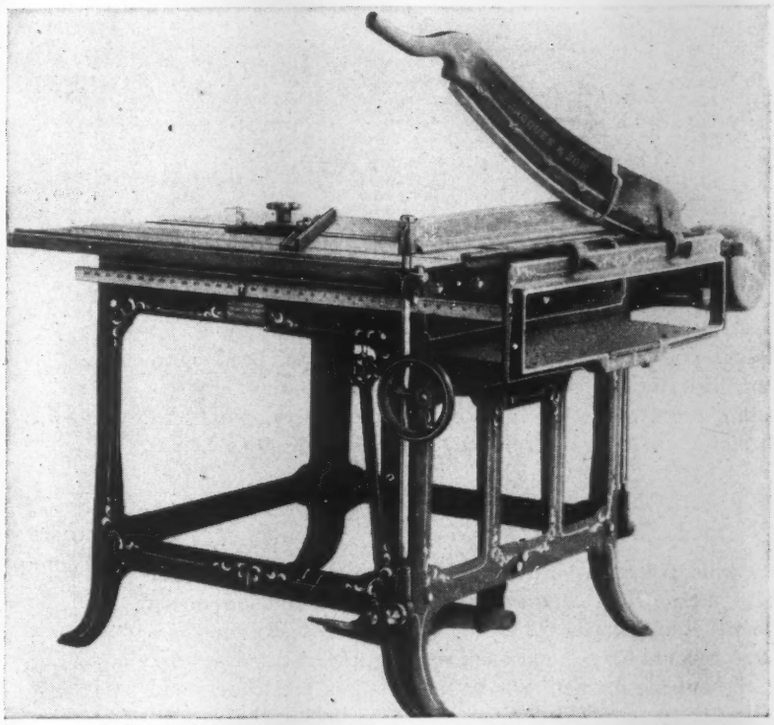


FIG. 1—OLD DESIGN. *This shear was made in individual pieces that had to be hand-fitted, drilled and bolted. Line production system was impossible.*

## THE DESIGN PROBLEM

In changing over the design to welded steel construction, the manufacturer analyzed the load requirements of the frame which consists essentially of four legs acting as columns and braces acting as beams. Resistance to deflection was the main consideration.

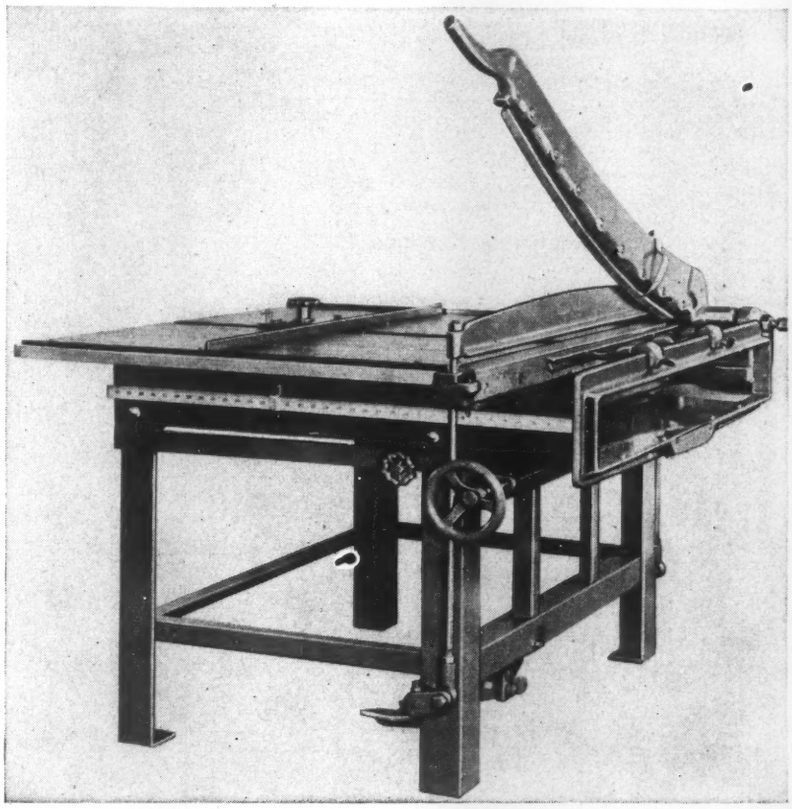


FIG. 2—WELDED DESIGN. *Hobbs engineers redesigned the shear for fabrication by arc welding. The new machine costs 60% less, weighs two-thirds less and is made by line production methods.*

For example, in studying the problem in light of the usual beam formula (see Page 496, 8th Edition, Lincoln Procedure Handbook), comparison can be made of the size of steel angles needed to replace the old material.

In simple designs such as this, however, the common sense formula, based on experience, should prevail. Sizes of members should be governed also by uncalculable demands of handling and shipment, when the machine often gets its roughest treatment.

## PRODUCTION PROCEDURE

The simple angle iron and plate design of the frame (see Fig. 2) permits a standardized line production. Angles and plate are shear cut to size, are fitted up in a simple welded fixture and tack welded. All joints are fillets or square butts, requiring no bevelling. Tacked assembly is then placed in a positioner and finish welded . . . all joints downhand for maximum speed. A little grinding off of corner welds of top table and drilling for attachments is all the machining that's required.

A series of Studies in Machine Design are published by The Lincoln Electric Company and are available without charge to engineers and designers. They may be obtained by writing The Lincoln Electric Company, Dept. 351, Cleveland 1, Ohio.

Advertisement

exponent whose value depends upon the type of disk.

Letting $r_m$ equal the radius at which the actual tangential stress is equal to the average given by Equation 39, then from Equation 38,

$$\frac{KA}{r_m^n}=K\int_{r_i}^{r_o}\frac{dA}{r^n}$$

$$r_m=\left[\frac{A}{\int_{r_i}^{r_o}\frac{dA}{r^n}}\right]^{1/n} \quad \text{.....(41)}$$

By solving for $\sigma_{tm}$ and $r_m$ and substituting in Equation 40 the value of $K$ for the disk may be obtained. When $K$ is known $\sigma_t$ can be calculated for any radius. This method may be somewhat shorter than the $S$ and $D$ method, but it does not give any values for radial stress. The integrations can be performed with sufficient accuracy by dividing the area of the half section into several parts and obtaining the area of each by means of a planimeter.

### Disk Profile Equations

Profile equations are sometimes used in the design of solid disks with external loading at their outside diameters. Knowing the external load, the designer may assume a value for $\sigma_{ro}$ and calculate the thickness of the disk at the outside diameter, or he may assume a thickness and calculate $\sigma_{ro}$. By substituting the initial thickness and $\sigma_{ro}$ in a suitable profile equation he is able to calculate the width of the disk at any radius.

Introducing $b$ as a variable, Equation 6 becomes

$$\frac{db}{b}+\frac{\rho\omega^2 r dr}{\sigma_r}+\frac{dr}{r}-\frac{\sigma_t}{\sigma_r}\frac{dr}{r}+\frac{d\sigma_r}{\sigma_r}=0 \quad \text{.....(42)}$$

Now if $\sigma_t$ and $\sigma_r$ were expressed as functions of $r$, the quantities in Equation 42 could be integrated between $r_o$ and $r$ or between $b_o$ and $b$. In this way, it is possible to solve for $b$ in terms of the variable $r$ and known quantities such as $b_o$, $r_o$, $\omega$, $\sigma_{ro}$, and $\sigma$. It should be noted that the equations for $\sigma_t$ and $\sigma_r$ must satisfy Equations 9 and 10.

Equations for $\sigma_t$ and $\sigma_r$ are usually based on the radial displacement equation given as follows:

$$m=pr^n+qr \quad \text{.....(43)}$$

where $p$, $q$ and $n$ are constants.

The general procedure is to select a value for $n$ and develop the profile and stress equations for the disk. Most values for $n$ are not very practical for design purposes, but the values 1 and 3 are sometimes used.

Using the value $n = 1$ in Equation 43 and substituting in Equations 9 and 10,

$$\sigma_t=\frac{E}{1-\mu^2}\left[\ (p+q)+\mu(p+q)\ \right]=\frac{E}{1-\mu}(p+q) \quad \text{.....(44)}$$

$$\sigma_r=\frac{E}{1-\mu^2}\left[\ \mu(p+q)+(p+q)\ \right]=\frac{E}{1-\mu}(p+q) \quad \text{.....(45)}$$

It can be noted that $\sigma_t$ equals $\sigma_r$ and both are constant. Therefore $\sigma$, which is equal to $\sigma_{ro}$, can be substituted for $\sigma_t$ and $\sigma_r$. Equation 42 becomes

$$\int_b^{b_o}\frac{db}{b}+\int_r^{r_o}\frac{\rho\omega^2}{\sigma}r dr=0$$

$$b=b_o(e)^{\gamma\omega^2(r_o^2-r^2)/772\sigma} \quad \text{.....(46)}$$

where $e = 2.71828$

When $n = 3$ in Equation 43, substituting in Equations 9 and 10 gives

$$\sigma_t=\frac{E}{1-\mu^2}\left[\ (1+3\mu)pr^2+(1+\mu)q\ \right]$$

$$\sigma_r=\frac{E}{1-\mu^2}\left[\ (3+\mu)pr^2+(1+\mu)q\ \right]$$

When $r = 0$, $\sigma_r = \sigma_t = \sigma$. Therefore, in terms of $\sigma$,

$$\sigma_t=\sigma+\frac{E(1+3\mu)}{1-\mu^2}pr^2=\sigma-\alpha r^2 \quad \text{.....(47)}$$

$$\sigma_r=\sigma+\frac{E(3+\mu)}{1-\mu^2}pr^2=\sigma-\beta r^2 \quad \text{.....(48)}$$

where $\alpha$ and $\beta$ are constants. When $r = r_o$, $\sigma_r = \sigma_{ro}$. Therefore:

$$\sigma_{ro}=\sigma-\beta r_o^2;\quad \sigma-\sigma_{ro}=\beta r_o^2$$

$$\beta=\frac{\sigma-\sigma_{ro}}{r_o^2}=-\frac{E(3+\mu)}{1-\mu^2}p$$

If $\sigma - \sigma_{ro} = M$, then

$$\beta=\frac{M}{r_o^2} \quad \text{.....(49)}$$

$$p=-\frac{(1-\mu^2)M}{E(3+\mu)r_o^2}$$

$$\alpha=\frac{(1+3\mu)M}{(3+\mu)r_o^2} \quad \text{.....(50)}$$

Differentiating Equation 48

$$d\sigma_r=-2\beta r dr;\quad r dr=-\frac{d\sigma_r}{2\beta}$$

Likewise

$$\sigma_r-\sigma_t=(\alpha-\beta)r^2$$

$$\frac{dr}{r}-\frac{\sigma_t}{\sigma_r}\frac{dr}{r}=\frac{\sigma_r-\sigma_t}{\sigma_r}\frac{dr}{r}=\frac{(\alpha-\beta)r dr}{\sigma_r}=\frac{(\beta-\alpha)}{2\beta}\frac{d\sigma_r}{\sigma_r}$$

Substituting the foregoing values in Equation 42, rearranging terms, and integrating,

$$\int_b^{b_o}\frac{db}{b}=\frac{1}{2}\left(\frac{\alpha}{\beta}-3+\frac{\rho\omega^2}{\beta}\right)\int_{\sigma_r}^{\sigma_{ro}}\frac{d\sigma_r}{\sigma_r}$$

$$b=b_o\left[\frac{\sigma_r}{\sigma_{ro}}\right]^{1/2(\alpha/\beta-3+\rho\omega^2/\beta)} \quad \text{.....(51)}$$

Since

$$\frac{\alpha}{\beta}=\frac{1+3\mu}{3+\mu};\ \frac{\alpha}{\beta}-3=-\frac{8}{3+\mu}$$

*Uniquely versatile...*

... this new, simple way to put lasting reproductions on products

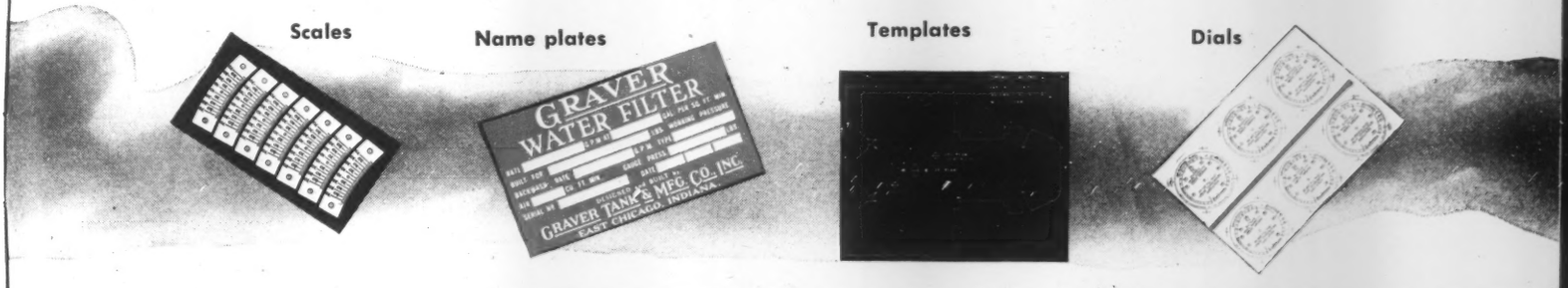
Kodak

# The KODAK TRANSFAX PROCESS

## Its application ... limited only by your own ingenuity

You can reproduce almost any marking directly on metal, plastic, any nonporous surface with utmost accuracy ... get crisp, clear images of drawings, designs, legends, lettering.

*Color effects* ... white Transfax can be applied on any color surface—using the color as the background, or reversed, using Transfax as the background—to give you a variety of color arrangements.




## Its operation ... fast, simple, inexpensive

1. Spray Transfax directly on the product's surface. With some surfaces a priming coat is necessary.
2. Place transparent or translucent original on sensitized surface and expose to strong light.
3. Wash with dilute Kodak Transfax Clearing Solution ... and overcoat with clear lacquer.

*The cost is low* ... neither darkroom nor special skill is necessary—and time required is as little as 5 minutes.

## It's long-lasting ... doesn't deteriorate with age

Transfax copies when overcoated are tough, rubproof, oilproof ... they don't deteriorate or change color with age ... and they have heat resistance sufficient to hold fast in flame cutting.

*Can TRANSFAX be used in your operation?*

Probably in more ways than you realize. Tell us about your product ... the marking you want to reproduce ... the type of surface involved. Let us send you complete information on the Transfax Process with full consideration for your particular needs.

**EASTMAN KODAK COMPANY**
**Industrial Photographic Division • Rochester 4, N. Y.**

# KODAK TRANSFAX PROCESS

**... a revolutionary new reproduction process**

# Silicone News

DC SILICONES

**DC Silicone Insulation Insures Motor Life!**

*Photo courtesy Automatic Transportation Company.*

It's human nature to want to beat the drums a bit when something you've put your sweat and capital into for years begins to pan out. We've been developing Silicone Insulation for years and giving silicone insulated motors the toughest testing electrical engineers could devise. We know it's the best electrical insulation there is. That confidence is now being justified.

Automatic Transportation Company of Chicago has announced that all of their new industrial trucks will be powered by DC Silicone insulated motors and lubricated with DC Silicone grease. That means a lot to us—and to you too. Engineers estimate that 20 to 50% of manufacturing costs goes into material handling. It costs you about $300, for example, to have a truck out of service while an armature is rewound.

Automatic Transportation is taking out insurance against such losses for you, by using Silicone Insulation. That kind of insurance is really necessary because there is no control over the kind of service industrial trucks get. They may have to lift 1,500 or 35,000 pounds. They may be used constantly or only part time. They may run over smooth floors or rough ones. A 2% grade doubles the torque on the motors.

That's why Automatic uses the best insulation there is. They put the best grease they can buy in the bearings. That's the DC 44 silicone grease, because it won't bleed into the windings or brushes. They also cushion the solenoid coils with Silastic*. Taken altogether, it's a nice example of how a conscientious, enterprising company can improve its product by using Dow Corning Silicones. These heat-stable, water-proof materials are described in Catalog No. B 1-4.

*TRADE MARK, DOW CORNING CORPORATION

**DOW CORNING CORPORATION**
**MIDLAND, MICHIGAN**

Chicago: 228 N. La Salle St.
Cleveland: Terminal Tower
Los Angeles: 634 S. Spring St.
New York: Empire State Bldg.
In Canada: Fiberglas Canada Ltd., Toronto
In England: Albright and Wilson, Ltd., London

Dow Corning
FIRST IN SILICONES

*Dow Corning Silicone Products include*

**FLUIDS**
Damping
Hydraulic
Dielectric
Waterproofing
Lubricating
Diffusion Pump
Mold Release

**GREASES**
High Temperature
Low Temperature
Valve Lubricants
Stopcock
High Vacuum

**COMPOUNDS**
Ignition Sealing
Antifoam A

**RESINS**
Electrical Insulating
Laminating
Protective Coatings

**SILASTIC***
Molding
Extruding
Coating
Laminating

*Trade Mark
Dow Corning
Corporation


Substituting these values

$$b = b_o\left[\frac{\sigma_r}{\sigma_{ro}}\right]^{(\gamma\omega^2/772\beta)-4/(3+\mu)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (52)$$

To use Equation 52 the designer selects a value for $\sigma$ which is the maximum stress in the disk. Next he selects a value for $\sigma_{ro}$ and calculates $b_o$ and $\beta$. Using Equation 48 he calculates values of $\sigma_r$ for various radii. He is now ready to substitute these values in Equation 52 to get values of $b$ for the various radii. It is sometimes necessary to try two or more combinations of $\sigma$ and $\sigma_{ro}$ before a suitable profile is obtained.

## Concluding Remarks

As a rule, the maximum stress in a rotating solid disk will be found at the center of the disk. For a disk with a central hole, the tangential stress at the bore is usually the maximum stress. In exceptional cases, external loading may set up radial stresses which exceed the maximum tangential stress.

An examination of Equations 22 and 24 reveals that for a constant-thickness disk with a very small hole at its center, maximum tangential stress will be slightly more than twice the stress in a solid disk of the same diameter. Increasing the diameter of the hole increases the stress. When the diameter is increased to the point where the disk becomes a thin ring, Equation 24 will approach Equation 4 and will give a value for $\sigma_t$ equal to the hoop stress in the thin ring.

Of course, external loading will increase the values of stresses in a disk beyond those given in Equations 22 and 24.

Radial displacement in any rotating disk can be found by using the following equation:

$$m = \frac{r}{E}(\sigma_t - \mu\sigma_r) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (53)$$

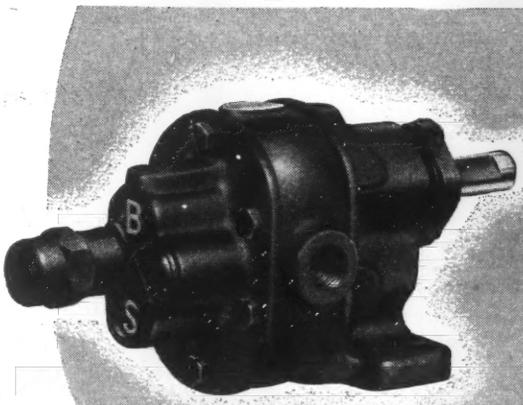
Values of radial displacement are sometimes required in order to calculate radial clearances between a rotating disk and its housing. For a disk with a central hole $\sigma_r$ will be zero at the bore. It is interesting to note from Equation 10 that the slope of the displacement curve will be negative at the bore. This seems to indicate that the material at the bore of the disk undergoes compression. Actually, the lack of radial loads on this material permits it to stretch more than the adjacent layers lying farther from the bore.

### Bibliography

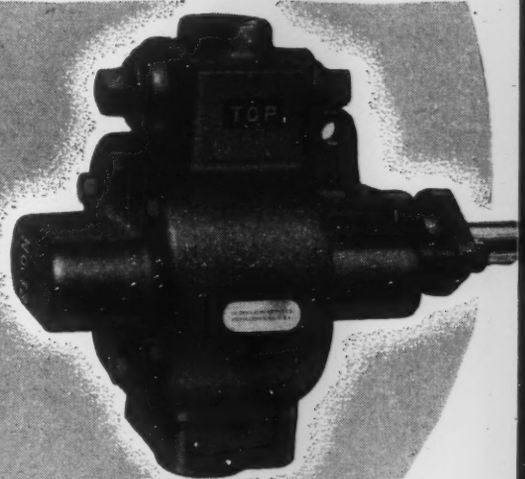

1. "Stresses in Cylindrically Shaped Rotors of Uniform Diameter"—C. M. Laffoon, *Transactions ASME*, Vol. 44 (#1858) 1922, Page 471.
2. "The Strength of Rotating Disks"—H. Haerle, *Engineering*, Vol. 106 August 9, 1918, Page 131.
3. "A Simplified Method of Determining Hoop Stresses in Fan Rotors"—G. F. Lake, *Journal of Applied Mechanics*, Vol. 12, No. 2, June, 1945, Page A-65.
4. *Steam and Gas Turbines*—A. Stodola, Loewenstein's Translation of 6th Edition, McGraw-Hill Book Co., Inc., New York, 1945, Vol. I, Pages 372 to 406.
5. *Die Berechnung Rotierender Scheiben und Ringe*—M. Donath, Berlin, 1912.
6. *Theory of Elasticity*—S. Timoshenko, McGraw-Hill Book Co., Inc., New York, 1934, Pages 66 to 70.
7. "A Simplified Method of Determining Stresses in Rotating Disks"—M. G. Driessen, *Transactions ASME*, Vol. 50, 1927-1928, Paper APM-50-10.
8. "Stresses in Rotating Disks at High Temperatures"—A. Stanley Thompson, *Journal of Applied Mechanics*, Vol. 13, No. 1, March 1946, Page A-45.
9. "Stress Distribution in Rotating Disks of Ductile Material After the Yield Point has Been Reached"—A. Nadai and L. H. Donnell, *Transactions ASME*, Vol. 51. 1929, Paper APM-51-16.

*Motor-Driven Centrifugal Pumps for coolant supply*

# Pumps that back up your design



*Rotary Geared Pumps for general purposes*



*Rotary Geared Pumps Reversible Type for general purposes*

*Rotary Geared Pumps for hydraulic service*

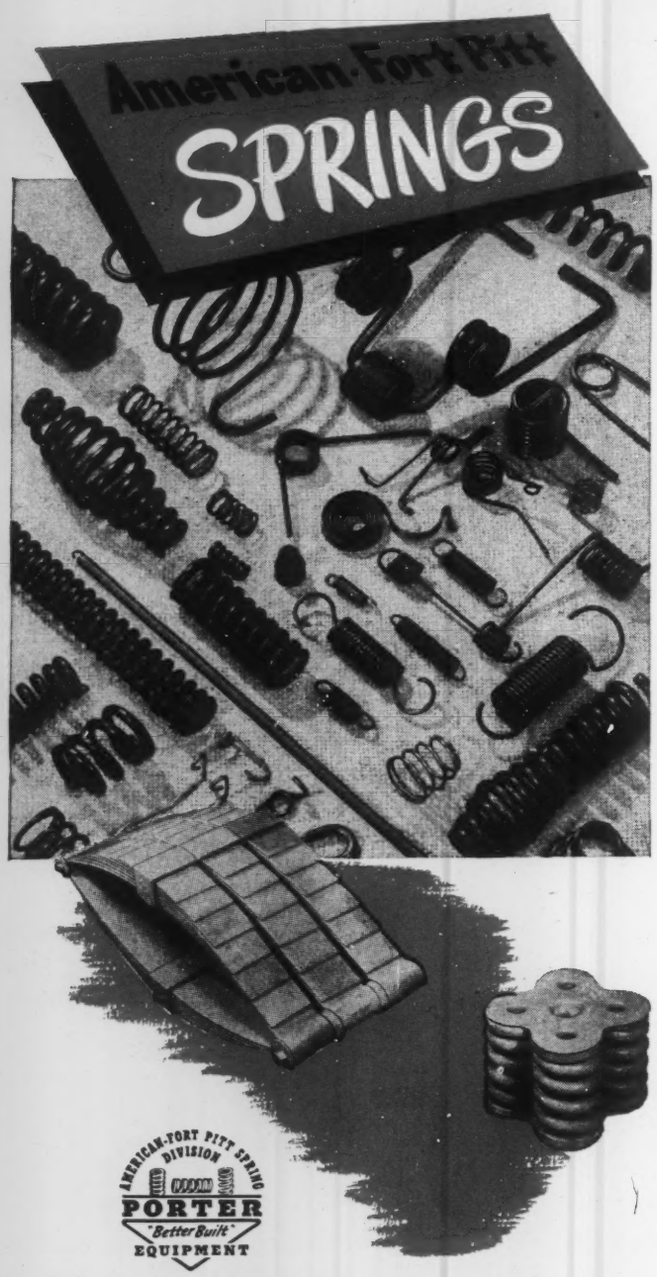
YOU'VE MADE SURE of everything about your machine design . . . including lubrication, coolant supply and hydraulic service. Now make sure that the pumps you specify back up your design—specify Brown & Sharpe Pumps.

Everything about these pumps . . . design, materials and manufacturing . . . is the result of long experience in fulfilling the pump requirements for machine tools and other machine equipment. The aim of Brown & Sharpe in making this complete line of pumps is to provide the correct type of service, a completely dependable service and an enduring service for every pumping need.

Write for pump catalog which gives detailed specifications on the complete line of Rotary Geared, Vane, Centrifugal and Motor Driven Pumps. Brown & Sharpe Mfg. Co., Providence 1, Rhode Island, U. S. A.

B·S *We urge buying through the Distributor* J·E

BROWN & SHARPE PUMPS




The merger of American Spiral Spring & Mfg. Co., and Fort Pitt Spring Co. has brought together two of the oldest spring manufacturers to form one of the *largest* spring producers in the country. This combined equipment and experience offers exceptionally complete facilities for the manufacture of all types of springs, from heavy coil and elliptic springs for cars and locomotives, to the smallest helical wire and flat springs for all purposes. Our engineering facilities are at your disposal to help solve your intricate spring problems.

**PORTER-BUILT *means* BETTER-BUILT**

**American-Fort Pitt Spring Division**
**H. K. PORTER COMPANY, Inc.**
PITTSBURGH 22, PENNSYLVANIA
*District Offices in Principal Cities*

# BUSINESS AND SALES BRIEFS

PREVIOUSLY district sales manager, John B. Girdler has been appointed assistant general manager of sales of the Vanadium Corp. of America, New York. He will continue to handle the company's sales in the eastern district.

♦

To provide better representation and service, Raybestos-Manhattan Inc. has opened a consolidated office at 1071 Union Commerce Bldg., Cleveland 14. Other Cleveland divisional offices have been combined in this office. Divisions of the company represented are as follows: Manhattan Rubber Division, by T. Robinson; Asbestos Textile & Packing Division, by D. E. Gow; and Equipment Sales Division and United States Asbestos Division, by E. E. Juergens. R. F. Tobin is office manager.

♦

Change of name to Central Aluminum Castings Corp. has been announced by Central Pattern & Foundry Co., 3737 South Sacramento Ave., Chicago 32. No other change has resulted.

♦

Acme Aluminum Alloys Inc. has appointed James E. Kendig as manager of its newly established eastern sales division at 702 Commercial Trust Bldg., South Philadelphia. The new office will handle sales and service on Acme's aluminum alloy castings in both sand and permanent mold, its tool and die division, pattern making and design or special engineering. Territory under the supervision of this office includes the eastern section of the United States, from Maine to North Carolina and as far west as Pittsburgh.

♦

Recently Western Aircraft Tool Co. moved into its newly erected office and factory building at 2505 North Ontario St., Burbank, Calif. Previously the company was located in Los Angeles.

♦

Two new representatives have been appointed by The Tomkins-Johnson Co., Jackson, Mich. They are: C. E. Hamilton, 1411 Fourth Avenue Bldg., Seattle; and A. B. Andrews Jr., Insurance Bldg., Raleigh, N. C. The company manufactures air and hydraulic cylinders, riveters, clinchers, die sinking milling cutters and air controls.

♦

Oscar Frohman has been named general sales engineer of Ampco Metal Inc., Milwaukee. Formerly he was manager of market development and will continue to carry out such work as is necessary in that capacity. James Arter, previously general sales engineer, has been appointed assistant to the general manager.

♦

Appointment of W. R. Persons as sales manager has been announced by The Lincoln Electric Co., Cleveland. Mr. Persons will report to C. M. Taylor, who recently was advanced to executive vice president. Also announced by the company are new locations of its branch offices in San Francisco, Los Angeles and Birmingham, Ala. The San Francisco office and warehouse is at 1302 Stanford Ave., Emeryville 8, Calif., and is under the direction of L. P. Henderson, district manager and welding engineer. J. B. McCormick is district manager and welding engineer in charge of the Los Angeles office and

# New self-wringing mop based on neoprene sponge...

Mop manufactured by The Spartan Company
Minneapolis, Minn.

**This new type mop** is designed to make easier many household tasks. And it's designed for long life too, because the "business end" is soft, absorbent neoprene sponge. Neoprene is tough, durable and abrasion-resistant; kitchen grease, hot soapy water and cleaning compounds have little effect on it. And it stays soft and resilient—gives long life where ordinary materials would soon fail.

**Neoprene gives toughness and grease-resistance**

HAVE you a problem involving toughness and grease-resistance, or any of the other features outlined below? Investigate the properties of neoprene. We'll furnish you complete technical information. Du Pont does not manufacture finished neoprene products, but we'll work with your supplier or help you find an adequate source.

Write today for your free subscription to *The Neoprene Notebook*. Its stories about others who use neoprene to solve their design problems will give you valuable ideas. E. I. du Pont de Nemours & Co. (Inc.), Rubber Chemicals Division, Wilmington 98, Delaware.

Design for success with

# NEOPRENE

The versatile synthetic rubber

**THIS DU PONT SYNTHETIC RUBBER DOES MANY JOBS SO WELL**

- Gives high tensile strength and resilience; low permanent distortion.
- It's tough and durable; resists abrasion, cutting, and chipping.
- Gives best resistance to sunlight, aging, ozone, and heat.
- Resists deterioration from oils, solvents, chemicals, acids.
- Gives peak air-retention; low permeability to gases and fluids.
- Special compositions can be made flame-retarding, static-conducting, or flexible at low temperatures.

BETTER THINGS FOR BETTER LIVING
. . . *THROUGH CHEMISTRY*

DU PONT

REG. U. S. PAT. OFF.

**with CHICAGO "SAFETY PLUS" PRODUCTS**

There's no "second reaching" to find a fit when Chicago "Safety Plus" fastenings are used in your assemblies. Dimensional uniformity in Chicago Screw Products is the result of close tolerance testing through each step of production. A thousand fit as perfectly as one.

The Chicago Screw Company has no secret formula for its "Safety Plus" Socket Screw Products —their excellence is simply the result of accurate workmanship and the use of only the finest materials. You'll find them superior in every way.

**Chicago "SAFETY PLUS" line includes:**

Socket Head Cap Screws • Socket Set Screws • Stripper Bolts • Square Head Dog Point Set Screws • Socket Pipe Plugs • Keys for "Safety Plus" Products.

**Complete line includes:**

Hexagon Head Cap Screws • Square Head Cup Point Set Screws • Headless Set Screws • Fillister Head Cap Screws • Flat Head Cap Screws • Taper Pins • Milled Studs • Semi-Finished Hexagon Nuts • Semi-Finished Hexagon Castellated Nuts.

*These Fine Products are sold only thru Authorized Distributors*

THE CHICAGO SCREW CO.
ESTABLISHED 1872
1026 SO. HOMAN AVENUE CHICAGO 24, ILL.

warehouse located at 1500 Calzona St., P. O. Box 7336, Station L, Los Angeles 23. The Birmingham district office is located at 113 North Ninth St., with J. E. Durstine serving as district manager and welding engineer.

# MEETINGS AND EXPOSITIONS

**March 17-19—**
**American Institute of Mining & Metallurgical Engineers.** Seventy-fifth anniversary celebration and World Conference on Mineral Resources to be held at Waldorf-Astoria Hotel, New York. Frank T. Sisco, 29 West 39th St., New York 18, is secretary of the Metals Division.

**March 19-22—**
**American Society of Tool Engineers.** Fifteenth annual convention to be held at Rice Hotel, Houston, Tex. Jno. M. Cannon, 1666 Penobscot Bldg., Detroit 26, is director of public relations.

**March 22-27—**
**Fifth Western Metal Congress and Exposition,** sponsored by American Society for Metals, to be held in the San Francisco-Oakland Golden Gate area. Technical meetings and industrial exhibits will be at the Oakland Civic Auditoriums. W. H. Eisenman, secretary of the society and managing director of the congress and exposition, will be available for further information at Hotel Leamington, Oakland, Calif.

**March 31-April 2—**
**Midwest Power Conference,** sponsored by Illinois Institute of Technology, to be held at Palmer House, Chicago. Professor Stanton E. Winston, Illinois Institute, is conference director.

**April 7-10—**
**National Association of Corrosion Engineers.** Annual convention to be held at Palmer House, Chicago. Elton Sterrett, 905 Southern Standard Bldg., Houston 2, Tex., is executive secretary.

**April 9-11—**
**Society of Automotive Engineers Inc.** National aeronautic meeting (spring) to be held at Hotel New Yorker, New York. John A. C. Warner, 29 West 39th St., New York 18, is secretary and general manager.

**April 16-18—**
**Society of Automotive Engineers Inc.** Transportation meeting to be held at Stevens Hotel, Chicago. John A. C. Warner, 29 West 39th St., New York 18, is secretary and general manager.

**May 6-10—**
**Second National Plastics Exposition** to be held in conjunction with the annual meeting of the Society of the Plastics Industry. Conference headquarters will be at Stevens Hotel, Chicago, and exposition will be at Chicago Coliseum. William T. Cruse, 295 Madison Ave., New York 17, is executive vice president of the society.

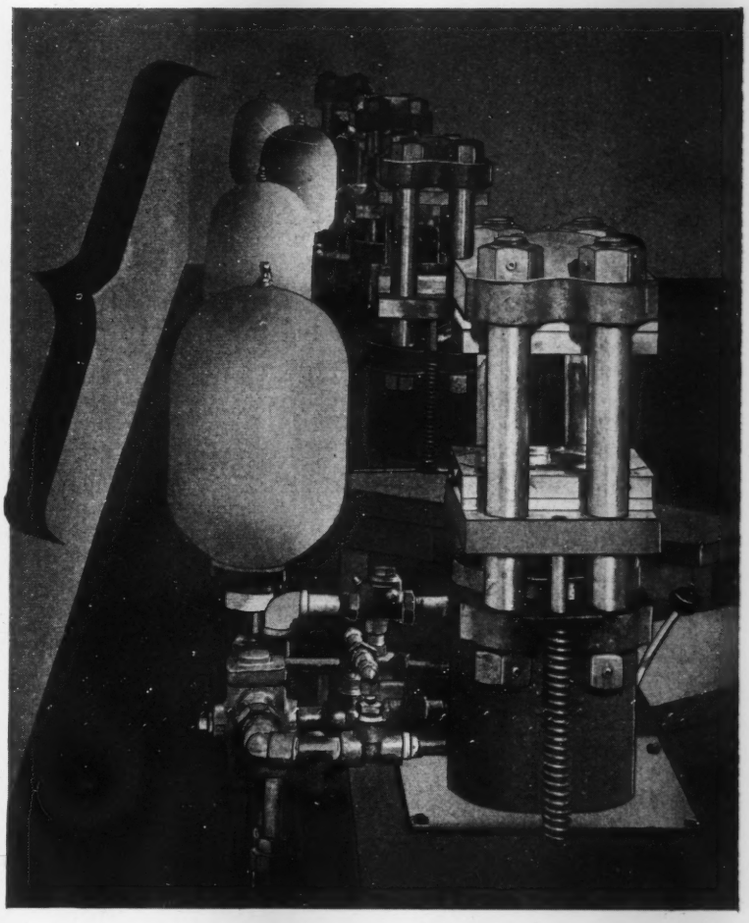
**May 15-17—**
**Society for Experimental Stress Analysis.** Annual meeting including a symposium on shock and impact to be held at Stevens Hotel, Chicago. Additional information may be obtained from the society at P.O. Box 168, Cambridge 39, Mass. W. M. Murray is secretary-treasurer.

**May 21-24—**
**American Society of Mechanical Engineers.** Oil and gas power nineteenth national conference to be held at Cleveland. Additional information may be obtained from headquarters of the society at 29 West 39th St., New York. C. E. Davies is secretary.

**May 22-31—**
**Mid-American Exposition** to be held at Public Auditorium, Cleveland. Parker Hill, vice president of the Cleveland Chamber of Commerce, is secretary.

**May 26-29—**
**American Society of Mechanical Engineers.** Aviation meeting to be held at Los Angeles. Additional information may be obtained from headquarters of the society at 29 West 39th St., New York. C. E. Davies is secretary.

Safety in Numbers



GREER HYDRAULIC ACCUMULATORS

Hydraulic presses work better and produce more when equipped with Greer Accumulators.

Some multiple press installations make use of one huge gravity-type accumulator for supplying fluid to a number of hydraulic presses. Failure of the accumulator causes stoppage of all presses until repairs are made.

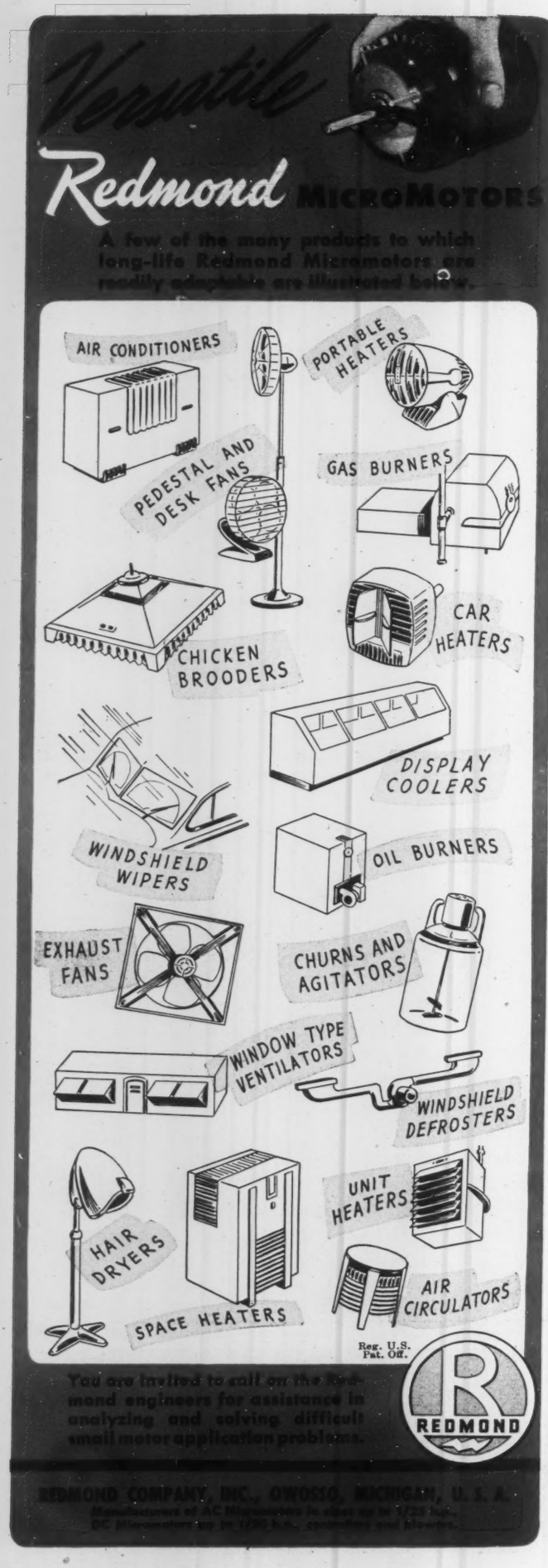
Eliminate those costly stoppages and keep production on-the-go by using one Greer Accumulator for each press. Then, if one press takes time out for repairs, the others will keep right on going. It's economical too, for several Greer units cost less than one gravity accumulator.

Buy yourself some cheap insurance against work stoppage. Remember, "There's safety in numbers." Send for Bulletin, Accumulators for Industry.

SALES REPRESENTATIVES:

**WATERMAN ENGINERING CO.**
721 Custer Ave., Evanston, Ill.
**INDUSTRIAL EQUIPMENT CO.**
170 Franklin St., Buffalo, N. Y.
**RAMSAY PUMP AND SUPPLY CO.**
1104—B Keenan Bldg., Pittsburgh, Pa.
**ROGERS & BAXTER**
2013 Olive St., St. Louis 3, Mo.
**LYTLE ENGINEERING CO.**
4500 Euclid Ave., Cleveland, Ohio
**URQUHART SERVICE**
1550 Blake St., Denver 2, Col.
**MALESON COMPANY**
5th and Chestnut Sts., Phila. 6, Pa.

GREER HYDRAULICS, Inc.
454 EIGHTEENTH ST., BROOKLYN 15, NEW YORK
WEST COAST OFFICE
320 S. ROBERTSON BLVD., BEVERLY HILLS, CAL.




# NEW MACHINES

## And the Companies Behind Them

**Air Conditioning**

Oil-fired winter conditioner, York-Shipley Inc., York, Pa.

**Ceramic**

Automatic hydraulic tile press, Hufford Machine Works, Redondo Beach, Calif.

**Cleaning**

Washer for nonmetallics, Allis Chalmers Mfg. Co., Milwaukee.

Turntable parts washing machine, Mabor Co., Clark Township, Rahway, N. J.

**Diesel**

5-60 hp, 6-cylinder diesel, The Buda Co., Harvey, Ill.

**Domestic**

5-tube battery radio, Westinghouse Electric Corp., Pittsburgh.

Cylinder type vacuum cleaner, Premier Vacuum Cleaner Division, General Electric Co., Cleveland.

Television receiver, Crosley Division, Aviation Corp., Chicago.

Rotary ironers, General Electric Co., Bridgeport 2, Conn.

**Electrical**

Hot blade wire stripper, Ideal Industries Inc., Sycamore, Ill.

Wire stripping machine, The Williams Products Co., Middletown, Conn.

**Finishing**

Variable speed polishing and buffing lathe, Hammond Machinery Builders, Kalamazoo 54, Mich.

Automatic buffing machine, Rhoads Machine Co., Los Angeles.

**Heat Treating**

Furnace for austempering and martempering, The A. F. Holden Co., New Haven 8 Conn.

Dust collector, Aget-Detroit Co., Ann Arbor, Mich.

**Industrial**

Extra low disk-type floor machine, G. H. Tennant Co., Minneapolis.

Dust collector, Aget-Detroit Co., Ann Arbor, Mich.

**Materials Handling**

Storage battery operated, low-lift platform trucks, Erie Foundry Co., Erie, Pa.

Towing tractor, Clark Tructractor, Battle Creek, Mich.

Portable electric hoists, Whiting Corp., Harvey, Ill.

Industrial shop tractor, The Buda Co., Harvey, Ill.

2000-pound capacity hand pallet truck, Lyon Raymond Corp., Greene, N. Y.

25-ton power truck, Elwell Parker Electric Co., Cleveland.

Skid lift truck, General Sales & Engineering Co., Chicago 4.

**Metalworking**

Hand-operated surface grinder, The DoAll Co., Minneapolis 4.

High-production automatic internal grinder, Bryant Chucking Grinder Co., Springfield, Vt.

Flat lapping machine, Spitfire Tools Inc., Chicago 41.

Electric hand grinder, The Dumore Co., Racine, Wis.

Multiple operation type machine for drilling, boring, reaming, facing and tapping operation, Baker Bros. Inc., Toledo.

Toggle machine for punching, Beatty Machine & Mfg. Co., Hammond, Ind.

**Mining**

25-ton, 480-hp high-speed electric mine haulage locomotive, Transportations Div., General Electric Co., Schenectady, N. Y.

**Rubber**

Hydraulic presses, Preco Inc., Los Angeles 1.

Floor tiling cutting machine, Campbell Machine & Development Co., Cuyahoga Falls, O.

Multiple opening platen press, R. D. Wood Co., Philadelphia 5.

**Testing**

"Airlectric" automatic gaging machine, Sheffield Corp., Dayton, O.

Vacuum tube bridge characteristic test set, Sylvania Electric Products Inc., Electronics Division, New York 18.

Grid pulse life test equipment, Evans Signal Laboratory, Belmar, N. J.

Cathode ray oscilloscope, Sylvania Products Inc., New York 18.

Horizontal external comparator, Sheffield Corp., Dayton, O.

Auxiliary power unit for test purposes, Superior Electric Co., Bristol, Conn.

**Textile**

Textile wrapping machine, Package Machinery Co., Springfield, Mass.

**Welding**

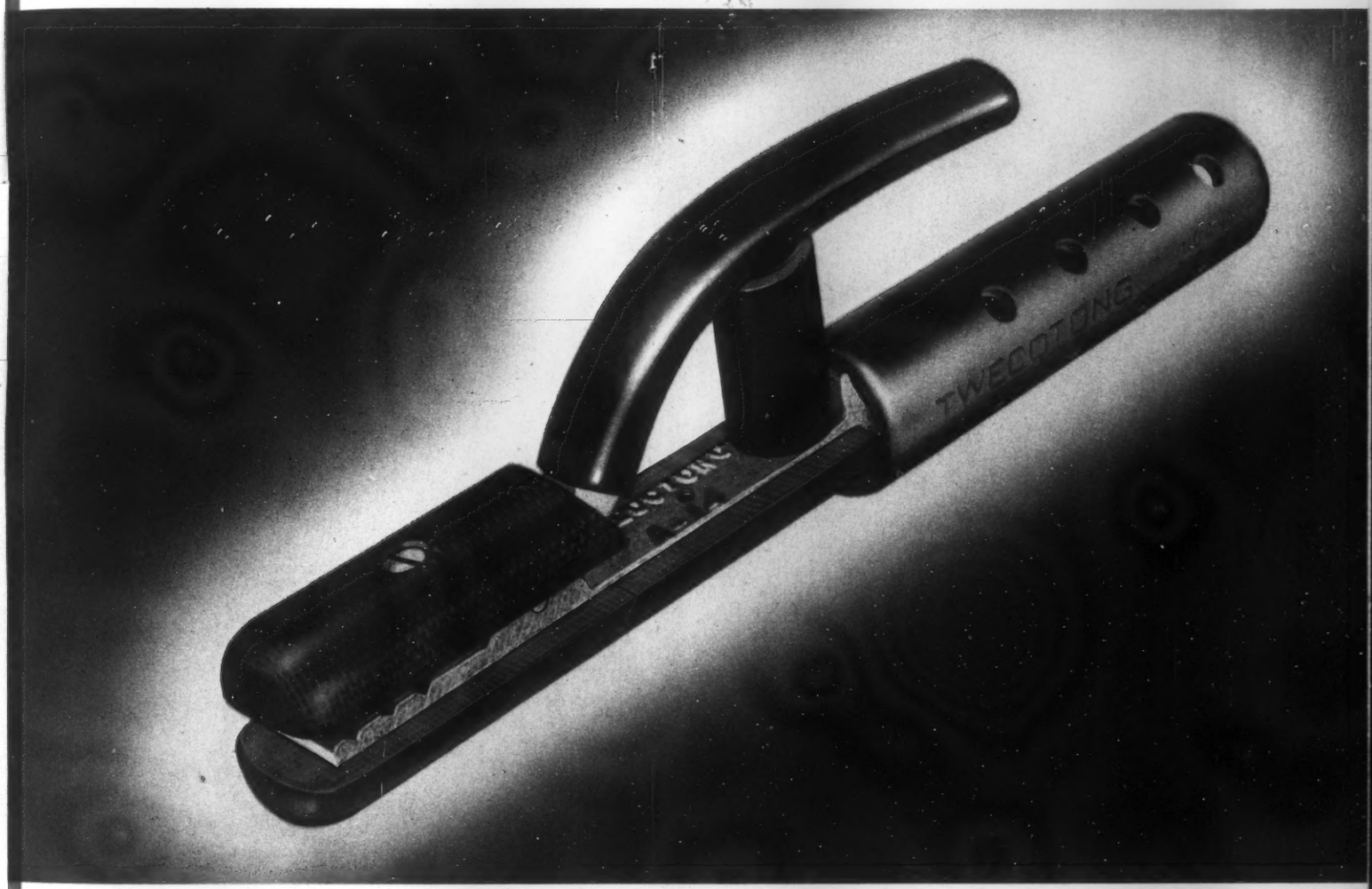
Air-operated spot welders, Pier Equipment Mfg. Co., Benton Harbor, Mich.

Flash welding machine, Sciaky Bros., Chicago.

Motor-driven flash welders, Progressive Welder Co., Detroit 12.

## *Plastics where plastics belong*

*The tip insulators on this welding electrode holder are excellent examples of the use of technical plastics where plastics belong . . . using resistance to heat and impact and electrical insulating properties. Synthane (our type of plastics) qualifies well for this job. Glass base laminated resists heat and impact fatigue, insulates and wears well. For these reasons and others, Synthane finds its way into an army of applications requiring electrical, chemical, mechanical or combined specifications.*




*If you have a use for Synthane, let us help you before you design. Perhaps we can save you time and trouble with design, materials or completely fabricated parts. Write for the complete catalog of Synthane Plastics and their applications today. Synthane Corporation, 5 River Road, Oaks, Penna.*

**SYNTHANE**

***where Synthane belongs***

DESIGN · MATERIALS · FABRICATION · SHEETS · RODS · TUBES
FABRICATED PARTS · MOLDED · MACERATED · MOLDED-LAMINATED

SYNTHANE TUBING FOR GENERAL AND
SYNTHANE SHEETS . . . Grades, finishes, sizes, colors,
FOR SYNTHANE SHEETS
general properties and uses
Get your copy before you plan with plastics
technical plastics
SYNTHANE
SYNTHANE CORPORATION
OAKS, PENNSYLVANIA
SYNTHANE CORPORATION, 5 RIVER ROAD, OAKS, PA.
Gentlemen:
Please send me without obligation the complete catalog of Synthane technical plastics.
Name
Company
Address
City Zone State
SYNTHANE
S
THIS COUPON BRINGS IT

## THEY SAVE A

# Big "BUNDLE OF LETTUCE"

**when vegetables are packed under VEEDER-ROOT "COUNTROL"**

SHE NUDGES A KNOB AT HER ELBOW when she finishes packing a crate, and that's all she has to do to tally her work as she goes along. Her nudge is acknowledged by a flashing light which indicates that each case has been recorded on the totalizator (shown at lower right on the bank of counters). Slow, old-fashioned check and tally methods are thrown out. Work speeds up. An up-to-the-minute total of production is always visible. And employee relations are improved. That's Veeder-Root *Count*rol.

Standard or special Veeder-Root Counting Devices, built into products as standard original parts, open up limitless possibilities for those products in the way of new uses, new convenience to users, new economies in operation. Find out how *you* can make *your product* count its way to new markets and profits. Just drop a note to the "Counting House," and say when you want an engineer to call.

(Above) Panel of 20 Veeder-Root Small Reset Magnetic Counters. Totalizing counter at lower right. Light in lower center flashes on whenever one of the 20 packers pushes a button.

(At right) Veeder-Root Small Reset Magnetic Counter, Form U. S. for AC only. Height: $5\frac{7}{32}$".

*The Counting House of Industry*

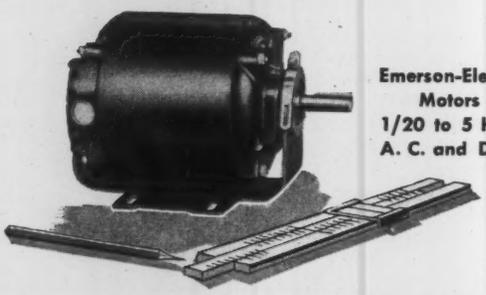
**VEEDER-ROOT INC.**

**Hartford 2, Connecticut**

*In Canada:* Veeder-Root of Canada, Ltd., 955 St. James St., Montreal 3. *In England:* Veeder-Root Ltd., Dickinson Works, 20 Purley Way, Croydon, Surrey.

# You're Not Seeing DOUBLE..

## They're TWIN-GINEERS at work



Emerson-Electric Motors
1/20 to 5 H. P.
A. C. and D. C.

To save costly re-designing and provide every possible manufacturing short cut, let Emerson-Electric Engineers collaborate with yours in "blue-printing" your new appliance or motor-driven equipment.

Although Emerson-Electric is booked solid on motor orders at present, Emerson-Electric Engineers have never been longer on engineering ideas, experience and skill—and never more willing to share these priceless advantages in suggesting and designing money-saving power applications for your present or future equipment.

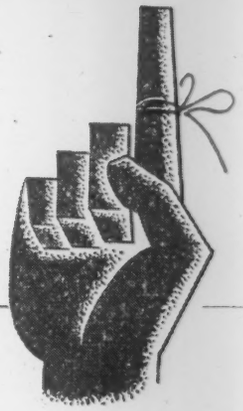
With *Twin-gineering*—your own *plus* Emerson-Electric's 57 years of engineering experience—you put your new product on the market with all the competitive advantages necessary for success.

**THE EMERSON ELECTRIC MANUFACTURING CO. • St. Louis 21, Mo.**
*Branches:* New York • Chicago • Cincinnati • Detroit • Los Angeles • Davenport
18

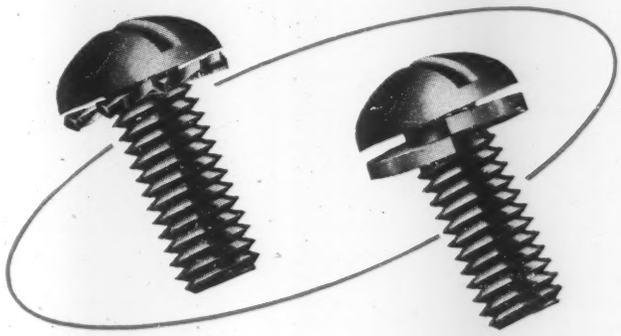
# EMERSON ELECTRIC

MOTORS · FANS — APPLIANCES

# no chance to forget



# the lock washer



Quality control is written into your purchase order when you specify SEMS, for SEMS bring you both screw *and* washer pre-assembled as a unit. The washer can't fall off!

Driving is easier, faster . . . no finger-fumbling, no lost washers. Inventories are always in balance. Remember, with SEMS you eliminate the entire washer and screw assembly operation right on your purchase order!

Write any listed manufacturer for free SEMS Data Book.

## use SEMS the *MODERN* fastener unit

**SEMS are Pre-Assembled Washer and Screw Units in which the Washer is held on the Screw by the Rolled Thread and is free to rotate.**

## SEMS ARE AVAILABLE FROM THE FOLLOWING MANUFACTURERS

**Corbin Screw Division**
The American Hardware Corp.
New Britain, Conn.

**Eaton Manufacturing Co.**
Reliance Division
Massillon, Ohio

**The Lamson & Sessions Co.**
Cleveland, Ohio

**National Lock Co.**
Rockford, Illinois

**The National Screw & Mfg. Co.**
Cleveland, Ohio

**New England Screw Co.**
Keene, N. H.

**Pheoll Manufacturing Co.**
Chicago, Illinois

**Russell, Burdsall & Ward**
Bolt & Nut Co.
Port Chester, N. Y.

**Scovill Manufacturing Co.**
Waterville Division
Waterville, Conn.

**Shakeproof Inc.**
Division of Illinois Tool Works
Chicago, Illinois

**Steel Co. of Canada, Ltd.**
Hamilton, Ont., Canada

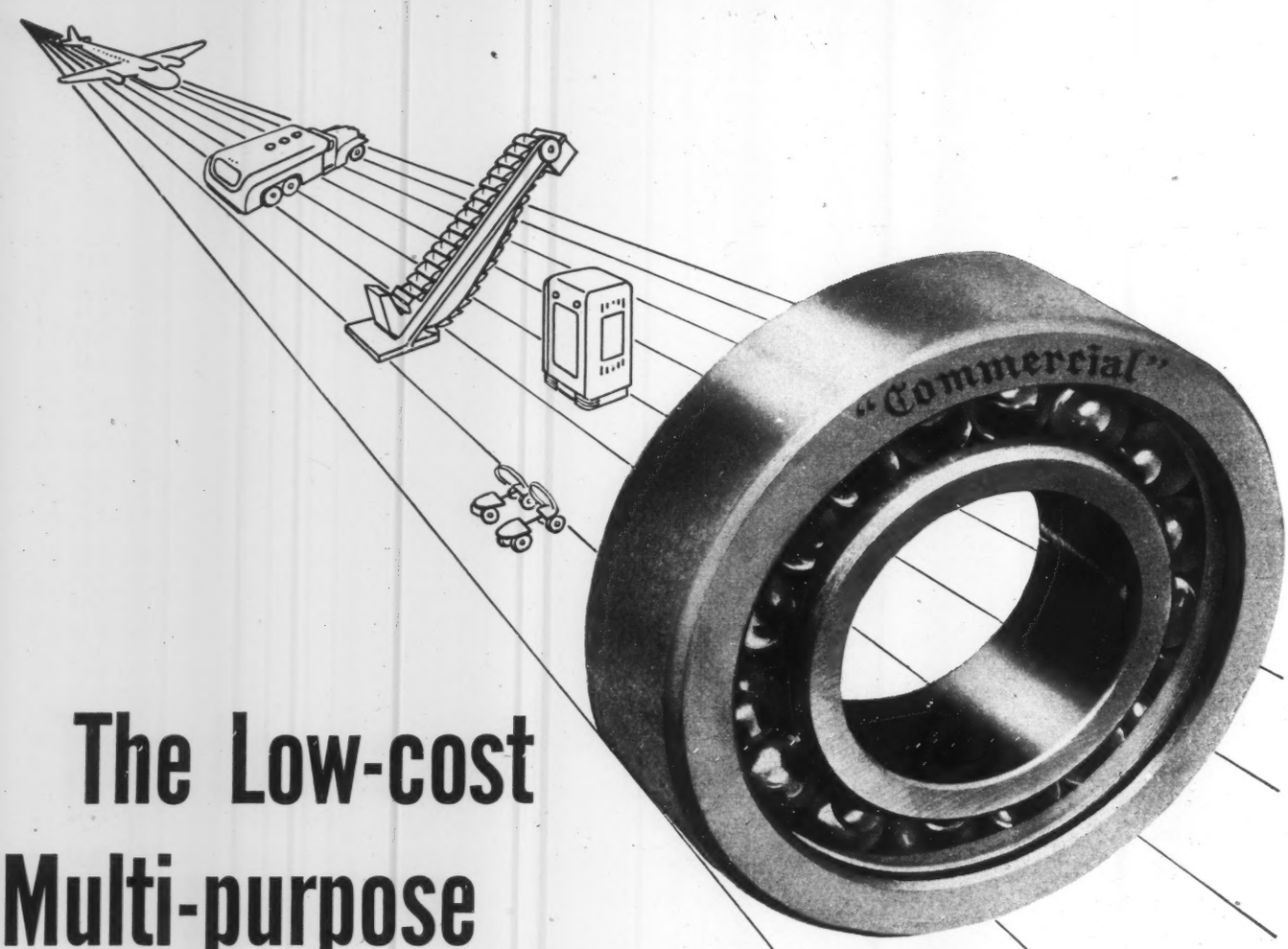
**Stronghold**
Screw Products Inc.
Chicago, Ill.

**American Screw Co.**
Providence, R. I.

**Central Screw Co.**
Chicago, Ill.

**Chandler Products Corp.**
Cleveland, Ohio

**Continental Screw Co.**
New Bedford, Mass.




# The Low-cost Multi-purpose Ball Bearing

Schatz "Commercial" Ball Bearings are equally at home in portable tools, oil burners, gravity conveyors and airplanes ... among others. That's why they've come to be known as the all-around utility ball bearing, wherever anti-friction performance is the need and low cost the problem.

The reason they fill the bill so well when "rugged" is written into the blueprint is their combination of high-grade, low-carbon, cold-rolled steel rings and through-hardened balls, which distinguish "Commercials" from other moderately priced ball bearings. This means extra-capacity, greater resilience and longer maintenance-free bearing life.

Schatz "Commercial" Ball Bearings cover the complete range of standard types and sizes ... are all alike in their low-cost, multi-purpose advantages. Fifty years of specialization in the manufacture of ball bearings have seen to that.

Write "Schatz-Commercials" into your specs ... then compare their on-the-job performance.

**SCHATZ**
"Commercial"
**BALL BEARINGS**

**THE SCHATZ MANUFACTURING COMPANY**
POUGHKEEPSIE, NEW YORK
REPRESENTATIVES LOCATED AT
Detroit: 2640 Book Tower—26 • Cleveland: 402 Swetland Building—15
Chicago: 8 S. Michigan Ave.—3 • Los Angeles: 5410 Wilshire Blvd.—36

# Available NOW on 24-Hour Shipment . . .

## R317T, Reynolds new strong aluminum alloy free-machining

# SCREW-MACHINE STOCK

***Are your screw-machines hungry for stock? Men idle? Orders unfilled?***

Then wire, write or phone us today for a supply of R317T, Reynolds new strong free-machining aluminum alloy screw-machine stock.

**24-HOUR SHIPMENTS**

R317T is now available in all standard sizes of rounds or hexagons for 24-hour shipment.

**ADVANTAGES OF R317T**

This new Reynolds Aluminum alloy is becoming famous for making any finished shape requiring free-machining. Weighing only ⅓ as much as steel or brass, it puts less strain on machine bearings—is easier on cutting tools—trims with small, free-falling, easily packed chips.

**R317T COSTS LESS**

Finished products of R317T cost less than brass because of light weight and small loss in cutting. Often you get a *better* finished product from this sturdy, durable, war-developed alloy.

R317T is superior to other aluminum alloys for machining because all cold-drawing strains are relieved with a final heat treatment in finished form—minimizing warp during machining.

**SOLVES YOUR PROBLEMS**

Reynolds R317T is the new screw-machine stock that may solve your problems now. Save time along your line! Fewer rejects! Finer production faster, at lower cost.

For 24-hour shipments or information, get in touch with the nearest Reynolds office or write, wire or phone Reynolds Metals Company, 2521 South Third Street, Louisville 1, Kentucky. *Offices in principal cities.*

**STANDARD STOCK AVAILABLE NOW**

17S-T, Reynolds standard screw-machine stock also available on 24-hr. shipment.

• • •

**STRUCTURAL SHAPES**

Quick shipment. Strong alloy aluminum rolled structural shapes.

**FORGINGS—FORGING STOCK**

Early shipment on all types and kinds of aluminum forging stock or press forgings contained in an area 7" x 16". Engineering help in designing dies.

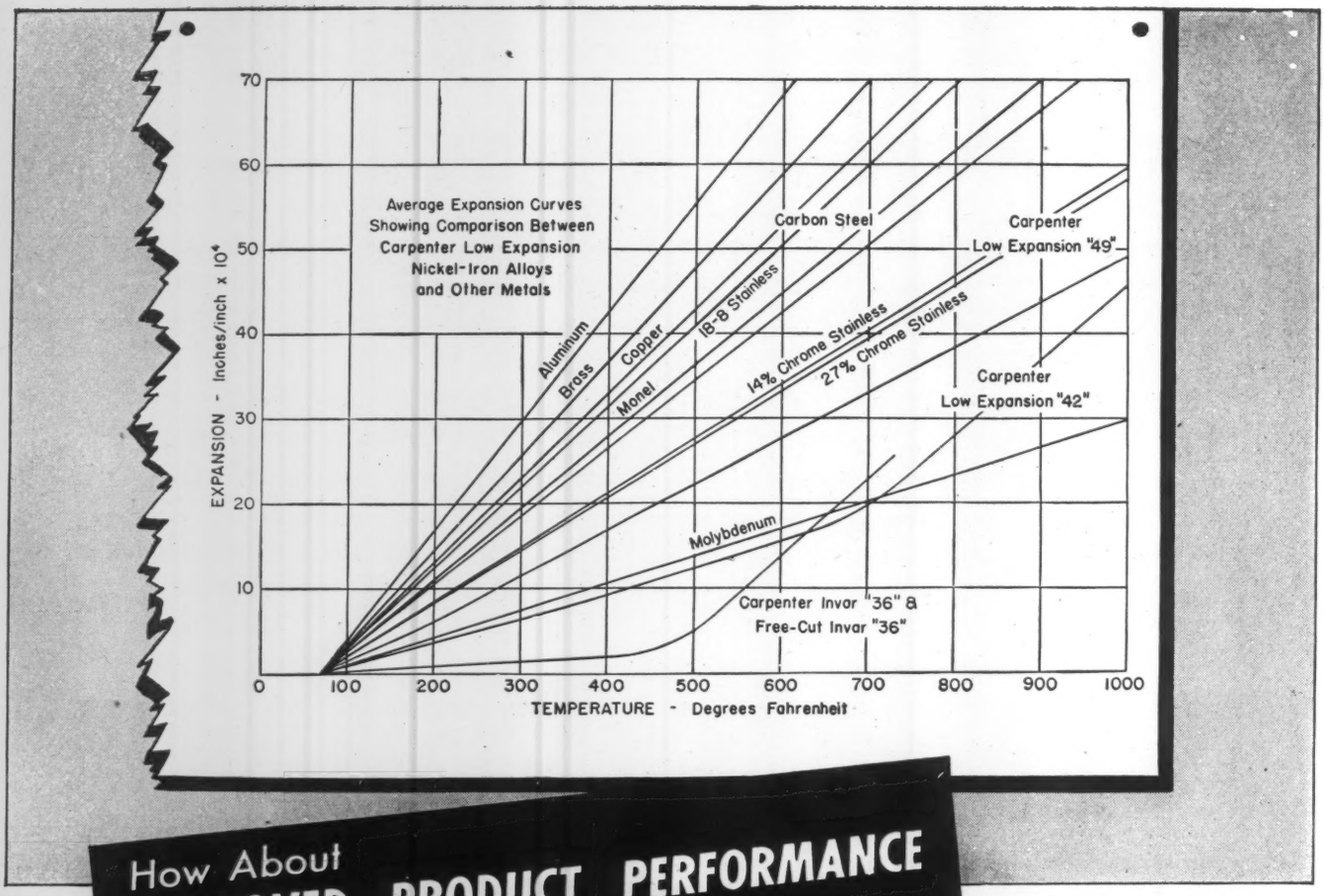
***Consult Reynolds for Aluminum NOW***

REYNOLDS METALS

# REYNOLDS ALUMINUM

*The Great New Source of*

INGOT · SHEET · SHAPES · WIRE · ROD · BAR · TUBING · FORGINGS · CASTINGS · FOIL · POWDER




## How About IMPROVED PRODUCT PERFORMANCE with these Low Expansion Alloys?

✓ *To provide movement*
*and*
✓ *To insure accuracy*
*( through various temperature ranges )*

To get Carpenter's 21-page bulletin of data on High Nickel Alloys, just drop us a note on your company letterhead, indicating your title.

### Check Uses In

- **Thermostats**
- **Automatic Switches**
- **Radio Condensers**
- **Wave Meters**
- **Electronic Controls**
- **High Precision Parts**
- _____
  *(Your Product)*

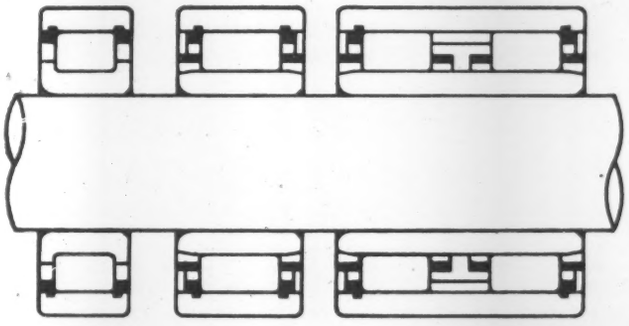
***The Carpenter Steel Company • 120 W. Bern Street • Reading, Pa.***

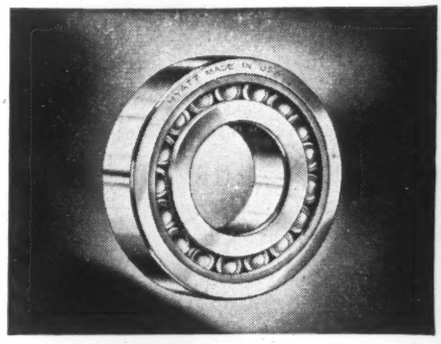
# *Carpenter* High Nickel Alloys

- Temperature Compensator "30"
- Carpenter Invar "36"
- Carpenter Free-Cut Invar "36"
- Glass Sealing "42"
- High Permeability "49"

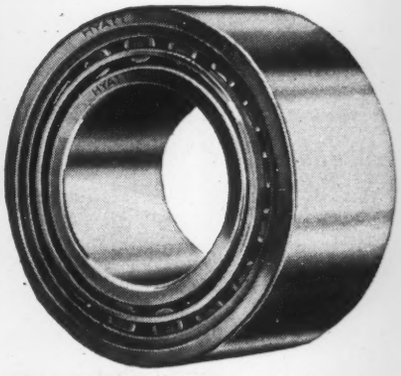
# IS BEARING SPACE LIMITED ↔ or ↕ ?

## *Hyatt has the Answers*

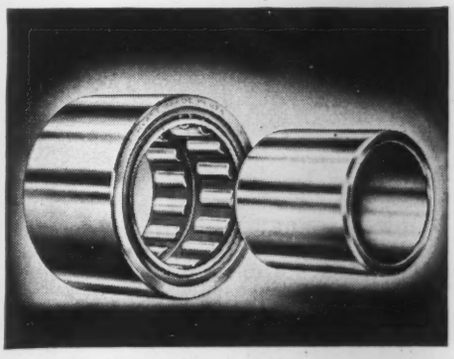




Hy-Load Bearing with full complement of rollers, providing maximum load carrying capacity in a given bearing space.



*5200 or 5300 Series* "Wide Width" Hy-Load Bearings — same bore size as 1200 or 1300 Series "Narrow Width" bearings, but races and rollers are longer.



*Duplex Type* Hy-Load Bearings — same bore size as a 5200 Series, but twice as wide and therefore much greater load carrying capacity.

Most efficient use of bearing space is but one of the advantages enjoyed by designers who know the Hy-Load line. Others include: option of omitted race operation, complete interchangeability of separable parts, adherence to standard AFBMA dimensions — and long, trouble-free life.

Full information about all 10 types of Hyatt Hy-Load Bearings (including dimensions and load ratings) is in the new 88-page Hy-Load Catalog . . . a complete engineering guide to radial bearing selection and use. Write now for a free copy, without obligation. Hyatt Bearings Division, General Motors Corporation, Box 71C, Harrison, New Jersey.

**HYATT ROLLER BEARINGS**

# Your hardest problem can be a "soft touch"

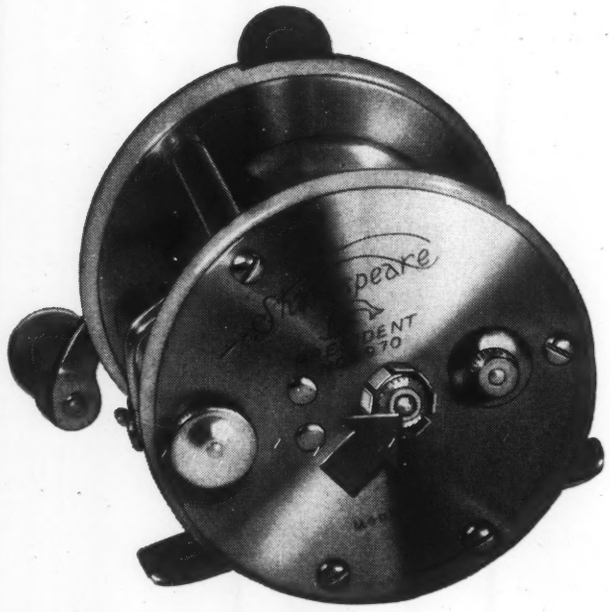
IF you have a hard problem to solve, it's apt to be a "soft touch" with Carboloy* Cemented Carbide.

This versatile metal is finding many new uses in many diversified fields, because it provides these 6 unusual properties:

- **High hardness**
- **Extreme density**
- **High abrasion resistance**
- **High modulus of elasticity**
- **High compressive strength**
- **Low coefficient of expansion**

The answer to *your* product or process problem may be in these properties. Carboloy blanks are available in many standard and special sizes and shapes.

**CARBOLOY COMPANY, INC.**
11141 E. 8 Mile Street • Detroit 32, Michigan

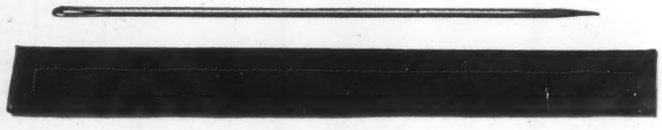


## The fishing reel that has no "bite"

A fishing reel manufacturer eliminated jamming from worn or scored bearings when he started using a Carboloy bushing at the critical point of wear. Now his reels run free, do not "bite" the line.

## The job that "couldn't be done"!

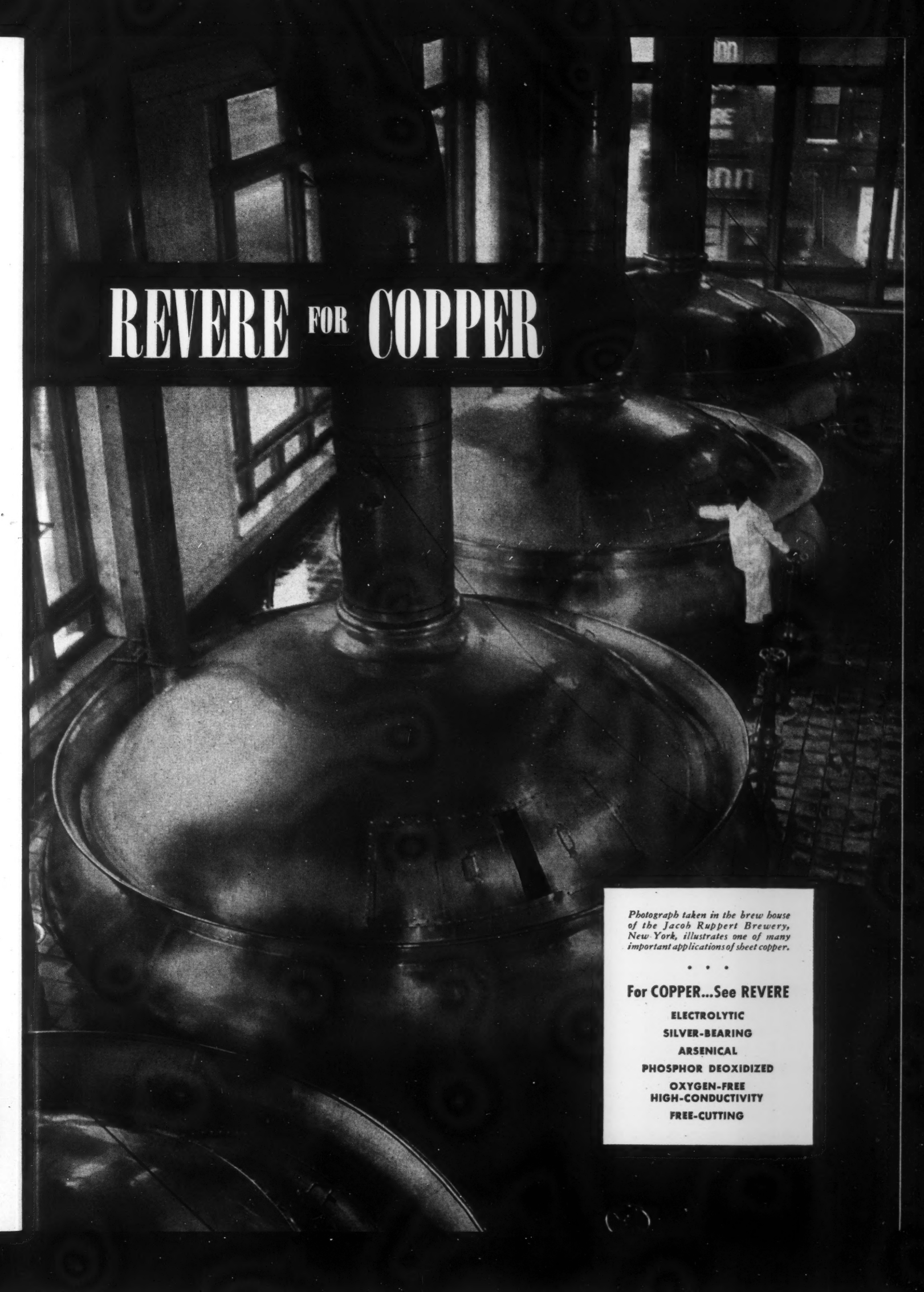
Problem: To bore a hole with a length 7.3 times the diameter; within .0002" round and straight. Solution: Use of a solid Carboloy Boring Bar. Its high modulus of elasticity, 84 million p.s.i., makes this job practical.



## The needle that gives a pointed lesson

A mattress manufacturer was hand-sewing the bead half way around, then the needle needed sharpening. He tried a Carboloy-tipped needle, has sewed 534 mattresses (160,200 holes) with it, and it is still sharp. Steel needles after 15 sharpenings were too short and had to be thrown away.

**CARBOLOY** (TRADEMARK) CEMENTED CARBIDE **HARD METAL**




*Photograph taken in the brew house of the Jacob Ruppert Brewery, New York, illustrates one of many important applications of sheet copper.*

• • •

**For COPPER...See REVERE**

**ELECTROLYTIC**

**SILVER-BEARING**

**ARSENICAL**

**PHOSPHOR DEOXIDIZED**

**OXYGEN-FREE HIGH-CONDUCTIVITY**

**FREE-CUTTING**

# REVERE COPPER

## "THE METAL OF INVENTION"

Revere considers its copper "The Metal of Invention" because it is so easily adaptable to such a wide variety of uses, applications and processes. Its easy workability sets the designer free; complicated parts and equipment can be produced easily and economically, while its many other inherent qualities make it invaluable.

Copper, however, is more than just *copper*. By making slight changes in composition, Revere copper is produced in six different types, each having special characteristics to meet varied needs with exactitude. If you need just the right copper to fill your requirements as to fabrication or use, come to Revere.

*General Qualities.* One of copper's most important qualities is its ability to resist corrosion. It withstands atmospheric conditions as satisfactorily as any available commercial metal, and in addition it is substantially immune to attack by a large number of chemicals . . . Copper also has high electrical and thermal conductivity . . . Fabricators find its hot and cold working properties unsurpassed. In cold working, reductions of 90% may be achieved without intermediate annealing. In hot working, temperature is not critical, the range of maximum plasticity being between 1200° and 1650° F. . . . Copper may be easily drawn, stamped, and formed by machine or hand, and easily soldered, polished, plated . . . Most coppers can be welded by gas, carbon arc or metal arc.

### ELECTROLYTIC COPPER

**Contains 99.9% copper, minimum.**

**Produced in sheet, strip, plate, rod, bus bar, tube, forgings.**

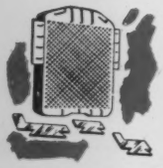
**Typical uses: Bus bar, commutators, roofing, flashing and gutters, kettles, vats, chemical and distillery equipment, forgings, printing rolls.**

Also known as tough-pitch copper, this is the most widely-used type of Revere copper, combining as it does high electrical and thermal conductivity with resistance to corrosion. Working properties: Cold working, hot working, soldering, polishing—excellent. Machining—fair. Welding—deoxidized copper preferred.

### SILVER-BEARING COPPER

**Copper 99.9% minimum; silver, 8 to 30 oz. per ton.**

**Produced in sheet, strip, rod, tube.**



**Typical uses: Radiators, gaskets for spark plugs, commutators, and other parts subjected to high temperatures, wherever copper is required to have high annealing qualities.**

The silver content of this copper raises its annealing temperature, so that the metal resists softening at 500° to 700° F. Electrical and thermal conductivity are the same as Electrolytic copper. Working properties: Cold working, hot working, soldering, polishing—excellent. Machining—fair. Welding—deoxidized copper preferred.

### ARSENICAL COPPER

**Copper 99.45%, arsenic 0.35%, phosphorus 0.025%.**

**Produced in tube form only.**

**Typical uses: Tubes for condensers and heat exchangers.**

This special copper has lower electrical and thermal conductivities than Electrolytic. Due to its resistance to the chemical action of certain corrosive media, arsenical copper has found some application in tubes for condensers and heat exchangers. Working properties are the same as Electrolytic.

### PHOSPHOR DEOXIDIZED COPPER

**Copper 99.9%, phosphorus 0.025%.**

**Produced in sheet, strip, plate, rod, tube.**

**Typical uses: Water, oil and refrigeration lines; heat exchangers, stamped and spun products and parts, welded construction of vats, tanks, stills and similar equipment.**

Has better forming and bending qualities than Electrolytic, hence its selection when severe forming is required. It is also generally preferred for welding applications because at welding temperatures it resists embrittlement by reducing gases. Working properties: Cold working, hot working, soldering, polishing—excellent. Machining—fair. Welding—excellent.

### OXYGEN-FREE HIGH-CONDUCTIVITY COPPER

**Copper 99.9% minimum**

**Produced in sheet, strip, rod, tube.**

**Typical uses: Drawn and stamped parts; metal-to-glass seals, as in vacuum tubes; equipment operated at elevated temperatures in presence of reducing gases.**

Revere Oxygen-Free Copper has excellent drawing and forming properties, similar to those of Phosphor Deoxidized, and retains the highest electrical conductivity. Because of its freedom from oxygen it does not become embrittled when exposed to reducing gases at elevated temperatures, as in forming seals with glass and similar applications. It is less suitable than Deoxidized Copper for general welding purposes because of the absence of residual deoxidant. Working properties: Cold working, hot working, soldering, polishing—excellent. Machining—fair. Welding—neutral flame or arc.

### FREE-CUTTING COPPER

**Copper 99.75%, tellurium 0.70% maximum.**

**Produced in rod, extruded shapes.**

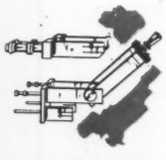
**Typical uses: Screw-machine products, electrical parts requiring accurate machining, welding torch tips, parts for electronic tubes.**

Revere Free-Cutting Copper is similar in qualities to Deoxidized Copper, but in addition has remarkable machinability, being rated in excess of 70% of free-cutting brass. Parts produced from it have close tolerances, an exceptional finish, sharp threads. Working properties: Cold working, hot working, soldering—good. Machining, polishing—excellent. Welding—not recommended.

## SPECIAL FORMS

### SPECIALLY-PREPARED SWITCH COPPER

**Copper 99.9%.**



Developed to bring new economy to manufacturers requiring flat copper conductors with a minimum of contact losses. Mirror finish is superior to commercial-quality copper bar, reducing costly polishing. Tolerances on flatness measured across width are unusually close. Working properties: Same as Electrolytic.

### COMMUTATOR COPPER

**Produced in lengths or segments.**

Commutator copper is made in the form you require, either in lengths of the proper cross-section, or in segments ready for assembly with a minimum of finishing. Offered in Electrolytic, Oxygen-Free High-Conductivity, or Silver-Bearing copper.

### FORGINGS AND EXTRUDED SHAPES

Revere produces forgings and extruded shapes in the types of copper suitable for such operations. These special forms, made to your specifications, may make possible remarkable economies in your plant; forgings will require a minimum of finishing operations; extrusions likewise. Consult Revere.

## OTHER REVERE COPPER PRODUCTS

**Fire extinguisher sheets, special temper and finish • Dairy sheets, specially rolled and heavily tinned • Anodes and anode hooks • Soldering coppers • Coppersmith sheets.**

**TECHNICAL DATA**—Technical data on the various types and forms of Revere Copper are available on request. Ask for the new edition of "Technical Information on Revere Copper and Copper Alloys."

**SELECTION OF COPPER**—Copper is one of the most useful and versatile of man's metals. Its applications are endless. Among the various types and forms of Revere Copper there must be one or more that match your needs perfectly. If you are contemplating a new use, having difficulty with the copper you now use, or wonder if a better choice can be made, the Revere Technical Advisory Service will gladly cooperate with you, making an analysis of all factors and making definite recommendations.

# REVERE

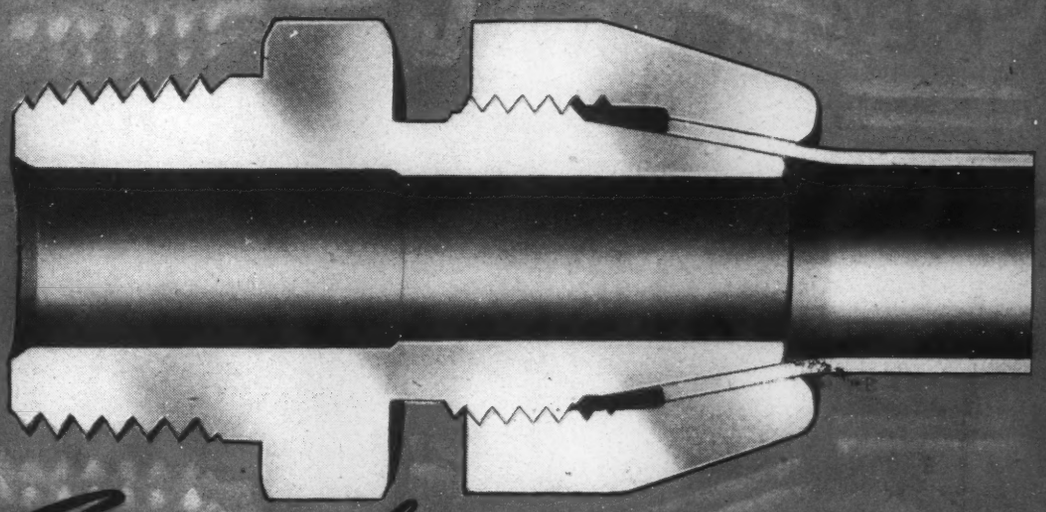
**COPPER AND BRASS INCORPORATED**

*Founded by Paul Revere in 1801*

230 Park Avenue, New York 17, New York

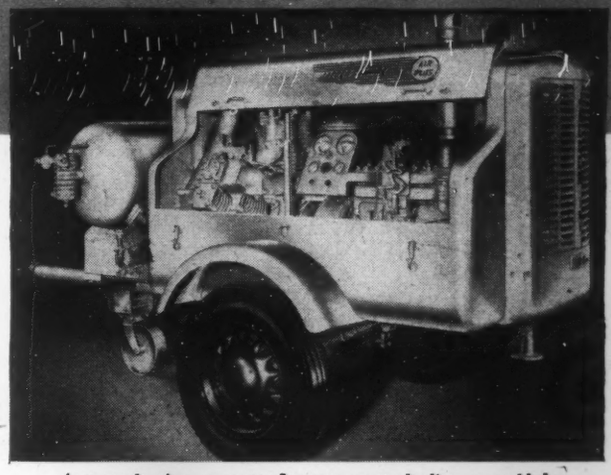
*Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; New Bedford, Mass.; Rome, N. Y.—Sales Offices in Principal Cities, Distributors Everywhere.*

# WHERE THERE'S VIBRATION UNDER HIGH PRESSURE



## Superseal

## FLARED TUBE FITTINGS



*As a result of severe tests, Jaeger now standardizes on welded steel tubing and SUPERSEAL fittings for 4 sizes of compressors.*

● Has the lack of a satisfactory fitting limited your use of light wall tubing where vibration and high pressure were present?

Then you will be interested in the findings of Jaeger Mfg. Co., which led to their standardizing on Superseal Flared Tube Fittings. Their test—running a compressor at full throttle for six hours at 600 lbs. pressure—proved that Superseal Fittings make a permanently leakproof joint unaffected by vibration, perform entirely satisfactorily with welded steel tubing using only a single flare. Fittings may be disconnected repeatedly without injury to the tubing.

### *Features of Superseal Fittings*

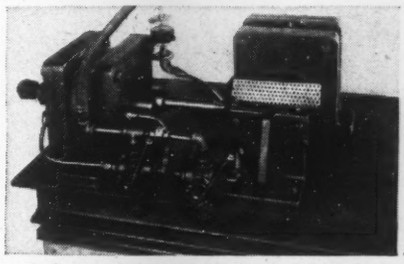
Long, smooth, tapered 10° flare on SUPERSEAL fitting and corresponding flare on inside of self-aligning nut hold tubing securely in place.

Materials: Stocked in brass and steel. Malleable iron, aluminum or alloys on order.

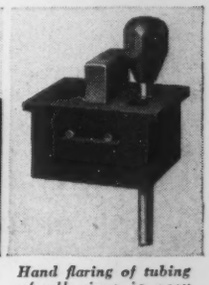
No shearing action to injure the tubing at the point of flare when the nut is tightened — the tubing is actually strengthened. Tubing bends can be made close to fittings.

Two part fitting . . . no rings, no sleeves.

***Approved by Underwriters' Laboratories for all hazardous gases and liquids.***



*Production flaring of tubing up to 2000 flares a day is possible with this flaring machine.*



*Hand flaring of tubing of all sizes is easy with this simple tool.*

*Write for new catalog, 4-R "Grinnell Superseal Flared Tube Fittings".*

GRINNELL COMPANY, INC.
*Executive Offices: Providence 1, R. I.*

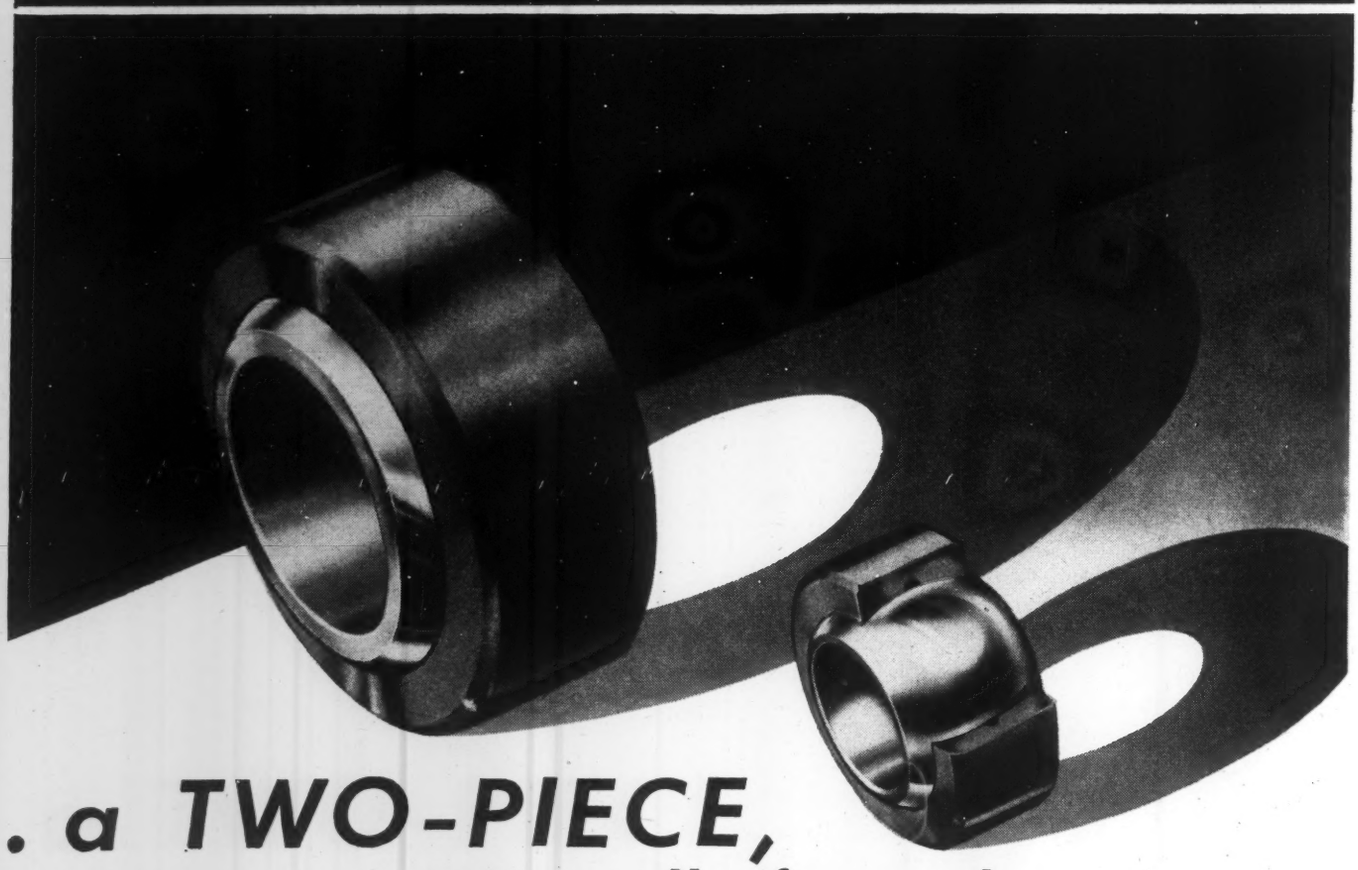
**BRANCH WAREHOUSES**

Atlanta 2, Ga.
Charlotte 1, N. C.
Chicago 9, Ill.
Cleveland 14, O.
Houston 1, Tex.
N. Kansas City 16, Mo.
Los Angeles 13, Cal.
Minneapolis 15, Minn.
New York 17, N. Y.
Oakland 7, Cal.
Philadelphia 34, Pa.
Providence 1, R. I.
Sacramento 14, Cal.
St. Louis 10, Mo.
St. Paul, Minn.
San Francisco 7, Cal.
Seattle 1, Wash.

GRINNELL

WHENEVER PIPING IS INVOLVED

# A NEW ADEL PRODUCT . .

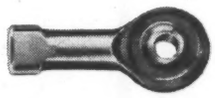


## . a *TWO-PIECE,* integrally-formed, self-aligning bearing.

The Adel *HALFCO* SPHERICAL-CONTACT BEARING consists of two inseparable parts: a hardened, highly-polished, precision-ground steel ball around which a hard bronze outer race is formed.

Adel HALFCO SPHERICAL-CONTACT BEARINGS surpass in maximum load capacity, and permit greater misalignment of mechanical elements than any other type of self-aligning bearing.

One of countless applications for which Adel HALFCO bearings are eminently suited is their use as self-aligning bearings for mechanical linkage rod ends.



HALFCO SPHERICAL-CONTACT BEARINGS are manufactured by Adel Precision Products Corp., under exclusive license, in accordance with U.S. and foreign patents pending.

**ADEL PRECISION PRODUCTS CORP.**

**BURBANK, CALIFORNIA** **HUNTINGTON, W. VA.**

**DESIGN SIMPLICITY – QUALITY – DEPENDABILITY**

## Designed for versatility...

Torrington Needle Bearings can be adapted to many applications with little modification of product design and minimum re-tooling. This feature enables Needle Bearings

## To meet your specific needs...

quickly and at low change-over cost.

In addition, Needle Bearings contribute to lower costs in design, fabrication, assembly and maintenance. They help promote compact, light-weight designs... can be housed in a plain bore without spacers or retainers... are installed by a simple arbor press operation... and operate at high efficiency with low maintenance cost.

To discover how easily the many advantages of Needle Bearings can be secured for your product, write for our Catalog #32, or consult our engineering staff on your specific friction problem.

**THE TORRINGTON COMPANY**

TORRINGTON, CONN. SOUTH BEND 21, IND.

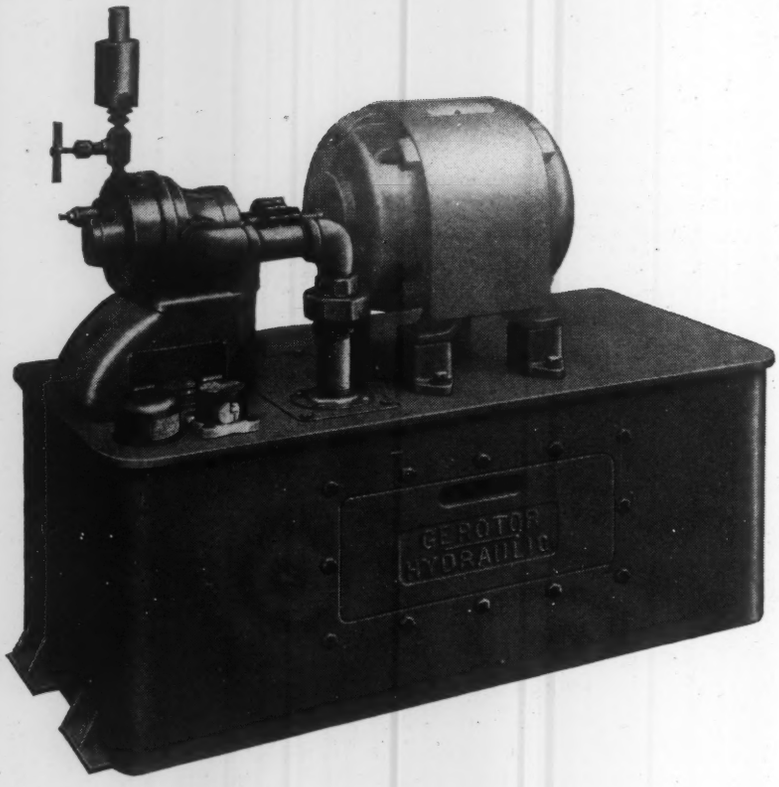
*Offices in all principal cities*

# TORRINGTON BEARINGS

• NEEDLE • SPHERICAL ROLLER • STRAIGHT ROLLER • TAPERED ROLLER • BALL •

# designed for efficiency

## GEROTOR HYDRAULIC PUMP UNITS




Available in series 9100 with single pumps . . . series 9200 with double pumps for two separate circuits

Deliver a steady oil flow at continuous pressures up to 1000 p.s.i.

(1200 p.s.i in some pump sizes)

An unbeatable combination . . . dependable Gerotor hydraulic pumps engineered into tank units complete with relief valve, gauges, filter and coupling. Gerotor pump units are standard for N.E.M.A. frame motors . . . adaptable to special motors, too. Write for catalog folder with full details . . . today!

GEROTOR MAY CORPORATION, BALTIMORE 3, MARYLAND

**GEROTOR**
**HYDRAULIC**
**pumps**
**valves**
**cylinders**

## Typical Products Made by "OHIO RUBBER"

ANTI-RATTLERS: (Rubber, All Kinds)
BOARDS: AUTO, Running (Rubber to metal)
BEARINGS: (Rubber)
BELTING: (Rubber)
BUMPERS: (Rubber) (Axle & Door)
BUMPERS: Screw, (Rubber)
CASTERS: Rubber Wheel
CHANNELS (OR SASH): (Rubber)
DIAPHRAGMS: (Rubber)
DISCS: Valve; Bib; etc.
FLOORING: Non-slip
GASKETS: Rubber and Rubber Cloth
GROMMETS: (Rubber)
HOSE: (Rubber)
GRIPS: (Rubber) for Handle Bars
HANDLES: (Hard Rubber)
INSULATION: (Rubber)
MATS: Auto (Rubber)
MOUNTINGS: Machinery, Motors, etc. (Rubber)
PACKINGS: (Rubber)
RINGS: (Rubber)
SEALS: Oil, Grease and Dirt
SLEEVES: Dredging; water pumps; (Rubber)
TAPE: Friction and Rubber
TIRES: Juvenile Vehicles
TIRES: Semi-Pneumatic
TREADS: Stair, Non-slip
TUBING: All types; (Rubber)
VIBRATION ABSORPTION PARTS: (Rubber)
WEDGES: (Window, Door, etc.)

THE OHIO RUBBER COMPANY

Orco-operation

WILLOUGHBY, OHIO

Factories: WILLOUGHBY, OHIO • LONG BEACH, CAL. • CONNEAUTVILLE, PA.

Branch Offices: DETROIT • NEW YORK • CHICAGO • INDIANAPOLIS • CLEVELAND • BOSTON

# *Up* 35,000,000 Lbs. Per Month

Production of Smelters' Aluminum Alloy Ingot has been increased tremendously over pre-war (1939) tonnage—from 10,000,000 to 45,000,000 pounds per month.

***But demand has increased even more!***

Every effort, consistent with production of top quality metal under strict laboratory control, is being made to increase production still further—to adjust the relationship of demand and supply.

For their patience and understanding during this period, members of Aluminum Research Institute express appreciation to their customers.

**William F. Jobbins, Inc.**
*Aurora, Illinois*

**R. Lavin & Sons, Inc.**
*Chicago 23, Illinois*

**The National Smelting Co.**
*Cleveland 5, Ohio*

**Niagara Falls Smelting & Refining Corp.**
*Buffalo 17, New York*

**North American Smelting Co.**
*Philadelphia 34, Pennsylvania*

**Sonken-Galamba Corporation**
*Kansas City 18, Kansas*

**U. S. Reduction Co.**
*East Chicago, Indiana*

**Aluminum and Magnesium, Inc.**
*Sandusky, Ohio*

**The American Metal Co., Ltd.**
*New York City 6*

**Apex Smelting Co.**
*Chicago 12, Illinois*

**Berg Metals Corporation**
*Los Angeles 11, California*

**The Cleveland Electro Metals Co.**
*Cleveland 13, Ohio*

**Federated Metals Division A. S. & R. Co.**
*New York City 5 and Branches*

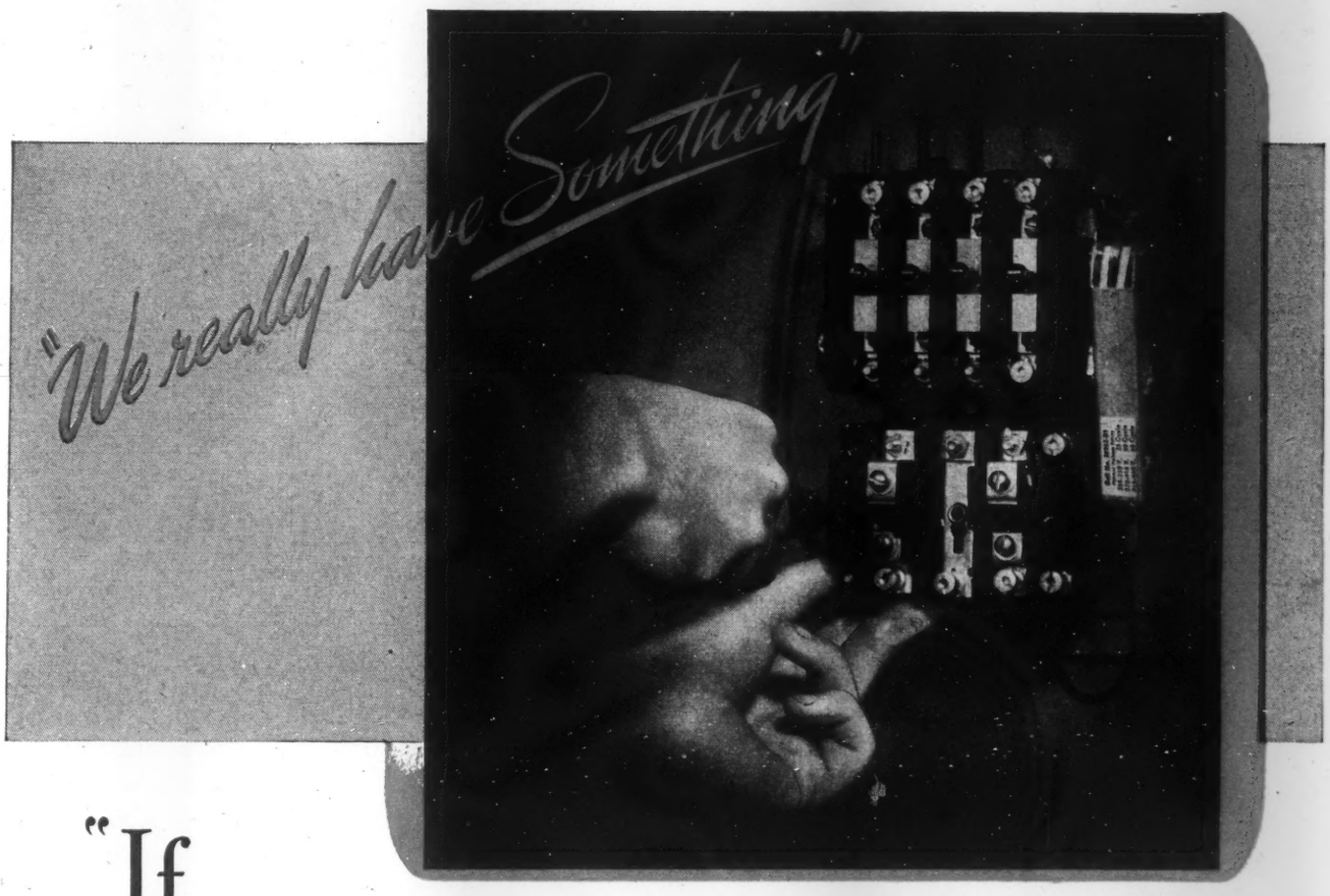
**General Smelting Company**
*Philadelphia 34, Pennsylvania*

**Samuel Greenfield Co., Inc.**
*Buffalo 12, New York*

MEMBER · ALUMINUM RESEARCH INSTITUTE

# Aluminum Research Institute

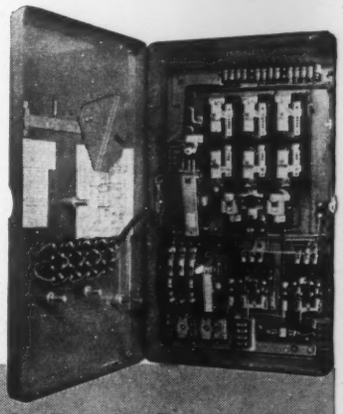
**111 West Washington Street • Chicago 2, Illinois**




"If you could come with me to the special assembly division at Plainville, you'd see what I mean. The day we took these pictures, for example, there was a multi-motor controller for a famous machine tool manufacturer, individual plug-in type control center units for a large oil refinery, the complicated fully automatic 'electric brain' for a paper making machine — all being manufactured on a standard production basis — *specials* in every sense of the word — but made from tried and proved Trumbull Electric basic components. Such basic components mean to you, as the customer, special controls with *standard* Trumbull performance.

"Standard design elements in the tremendously varied Trumbull production range make it possible for our customers' design engineers to specify special controls without running into a stone wall of excessive *special costs.*

"Of course, we of Trumbull can only try to give you a quick picture of a mighty good proposition in these few words. If you have a problem that indicates modern electrical control, it will be well worth your while to write now or come to our Plant and see for yourself. Trumbull engineers are good people to talk to — and work with."



**TRUMBULL (T) ELECTRIC**

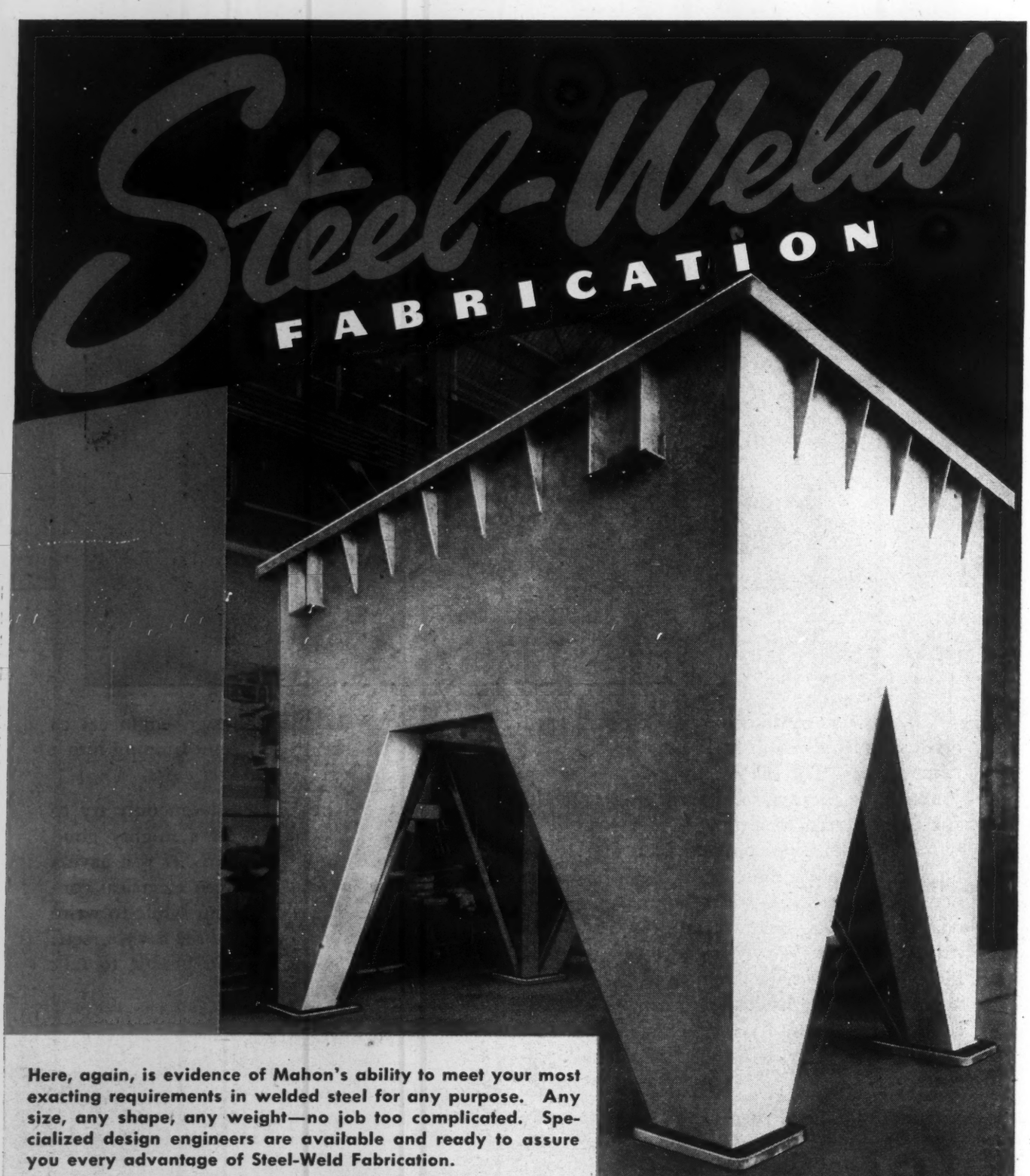
***MOTOR CONTROL***

**THE TRUMBULL ELECTRIC MANUFACTURING CO.**

PLAINVILLE, CONNECTICUT

OTHER FACTORIES AT NORWOOD, OHIO • LOS ANGELES • SAN FRANCISCO • SEATTLE

# Steel-Weld FABRICATION



Here, again, is evidence of Mahon's ability to meet your most exacting requirements in welded steel for any purpose. Any size, any shape, any weight—no job too complicated. Specialized design engineers are available and ready to assure you every advantage of Steel-Weld Fabrication.

Address STEEL-WELD DIVISION

THE R. C. MAHON COMPANY

Detroit 11, Michigan • Western Sales Division, Chicago 4, Illinois

One of 16 Twenty-Ton Press Bases Produced for an Automobile Manufacturer.

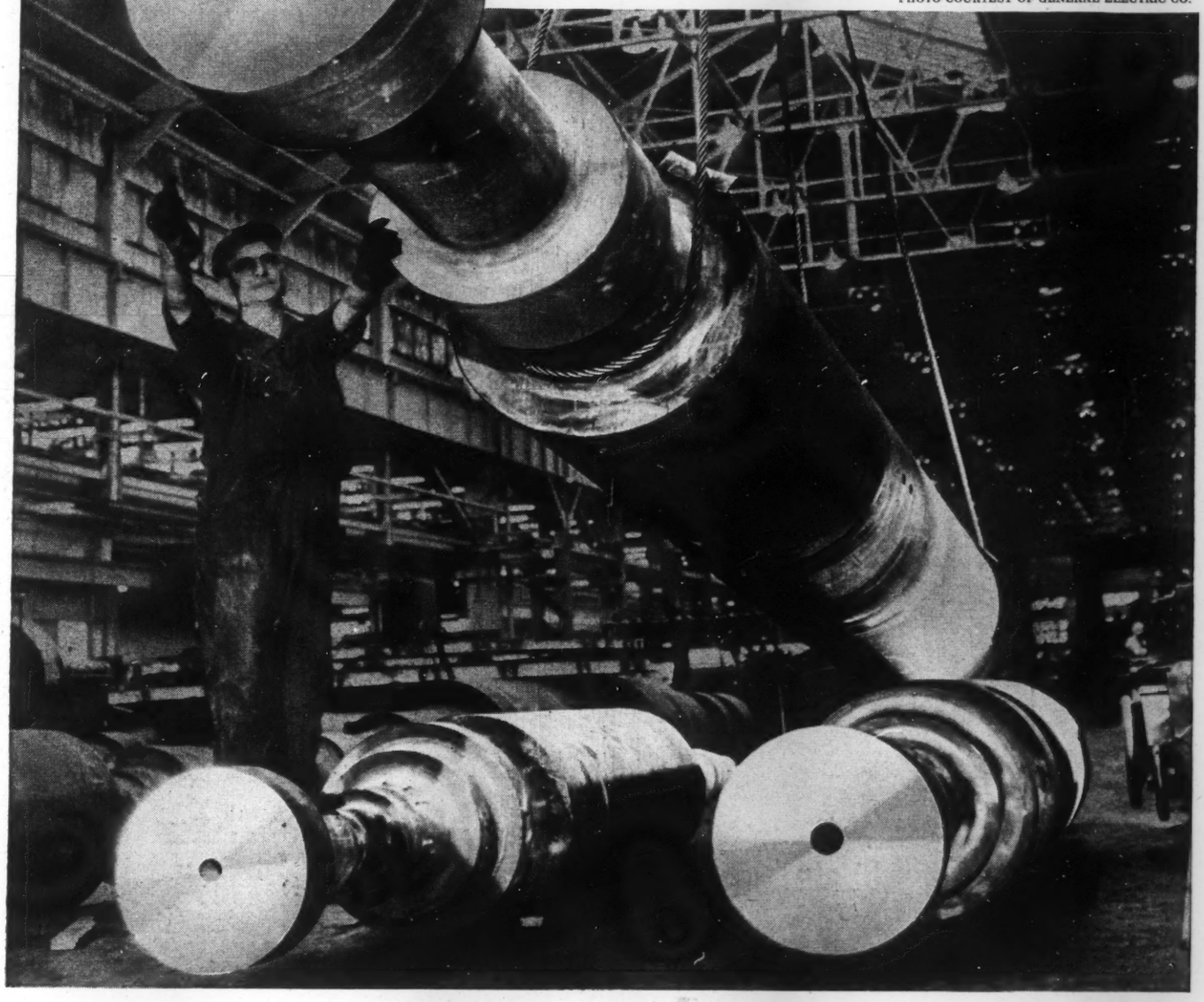
*Engineers and Fabricators of Welded Steel Machine Bases and Frames, and Many Other Welded Steel Products*

# MAHON

# Why NICKEL Alloy Steels Are Specified for Giant Generator Shafts

Alloy steel containing two and a half percent Nickel along with small percentages of other alloying elements give the heavy sections of this turbine rotor shaft the strength, toughness and endurance so vital to dependable performance. A yield strength of 80,000 p.s.i. combined with reduction of area consistently exceeding 36% in both radial and transverse directions was achieved in this heavy section.

PHOTO COURTESY OF GENERAL ELECTRIC CO.



## HEADED FOR THE LARGEST TURBO-GENERATOR OF ITS TYPE IN THE WORLD

This 75,000 pound Nickel alloy steel rotor shaft will serve in a new record size turbine generator rated at 100,000 KW, 77 feet long, 17 feet wide and designed for inlet conditions of 1250 p.s.i. and 1000° F.

INCO Nickel

TRADE MARK

Over the years, International Nickel has accumulated a fund of useful information on the selection, fabrication, treatment and performance of engineering steels, stainless steels, cast irons, brasses, bronzes and other alloys containing Nickel. This information and data are yours for the asking. Write for "List A" of available publications.

**THE INTERNATIONAL NICKEL COMPANY, INC.** 67 WALL STREET NEW YORK 5, N.Y.

# There is No Substitute For a Spring Washer

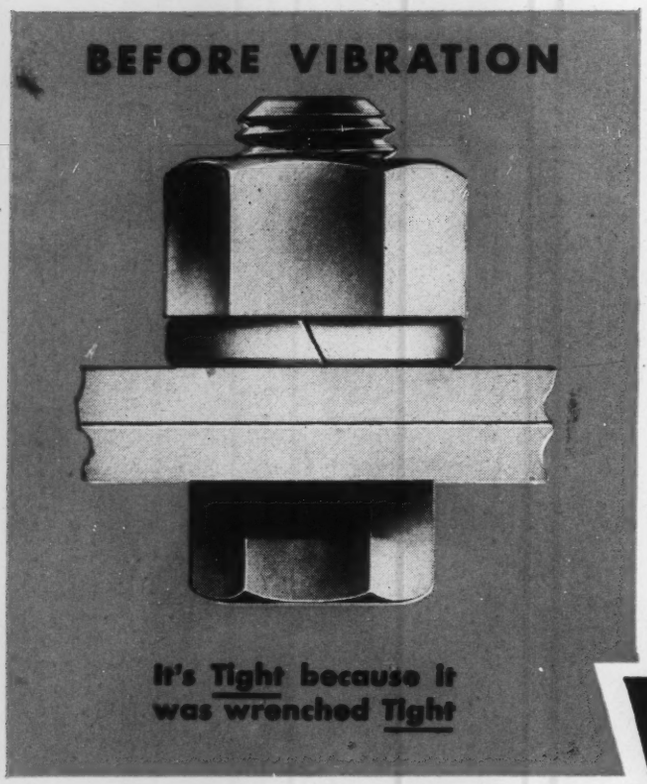
Every practical man knows that wear occurs when vibrating metal contacts metal; even when seemingly bolted tight.

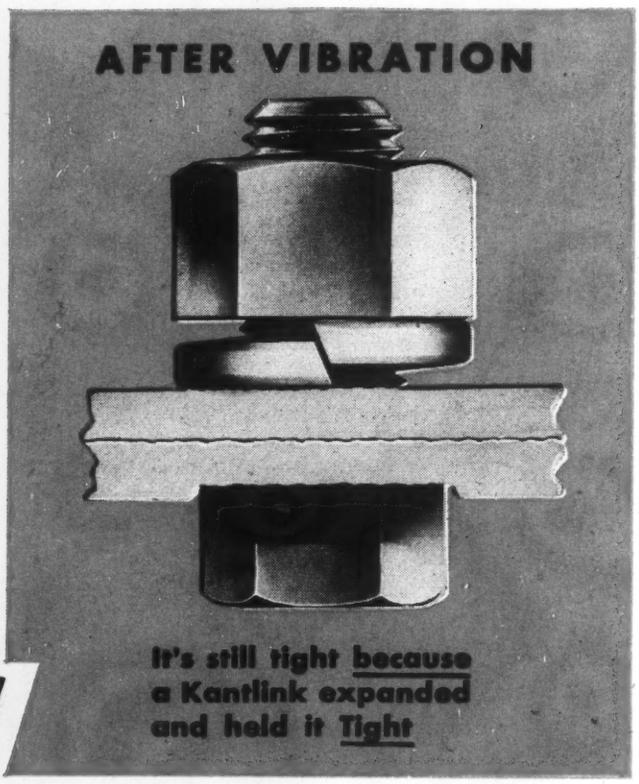
He knows that bolted assemblies loosen because of bolt stretch, and the frictional wear of burrs, flares, and the pulverizing of paint, scale and rust.

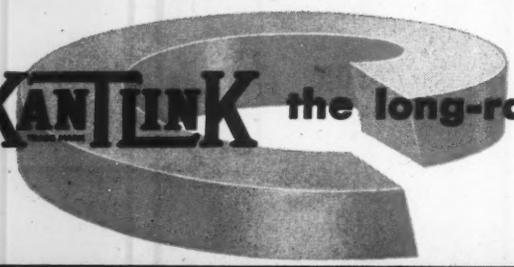
He knows that even if the nut never budges, the other parts of assemblies wear loose unless a strong spring washer is used to expand as wear occurs—to expand continually, over long range if necessary, to hold all parts tight longer.

There is no substitute.

On all assemblies specify Kantlink spring washers for real bolted security.



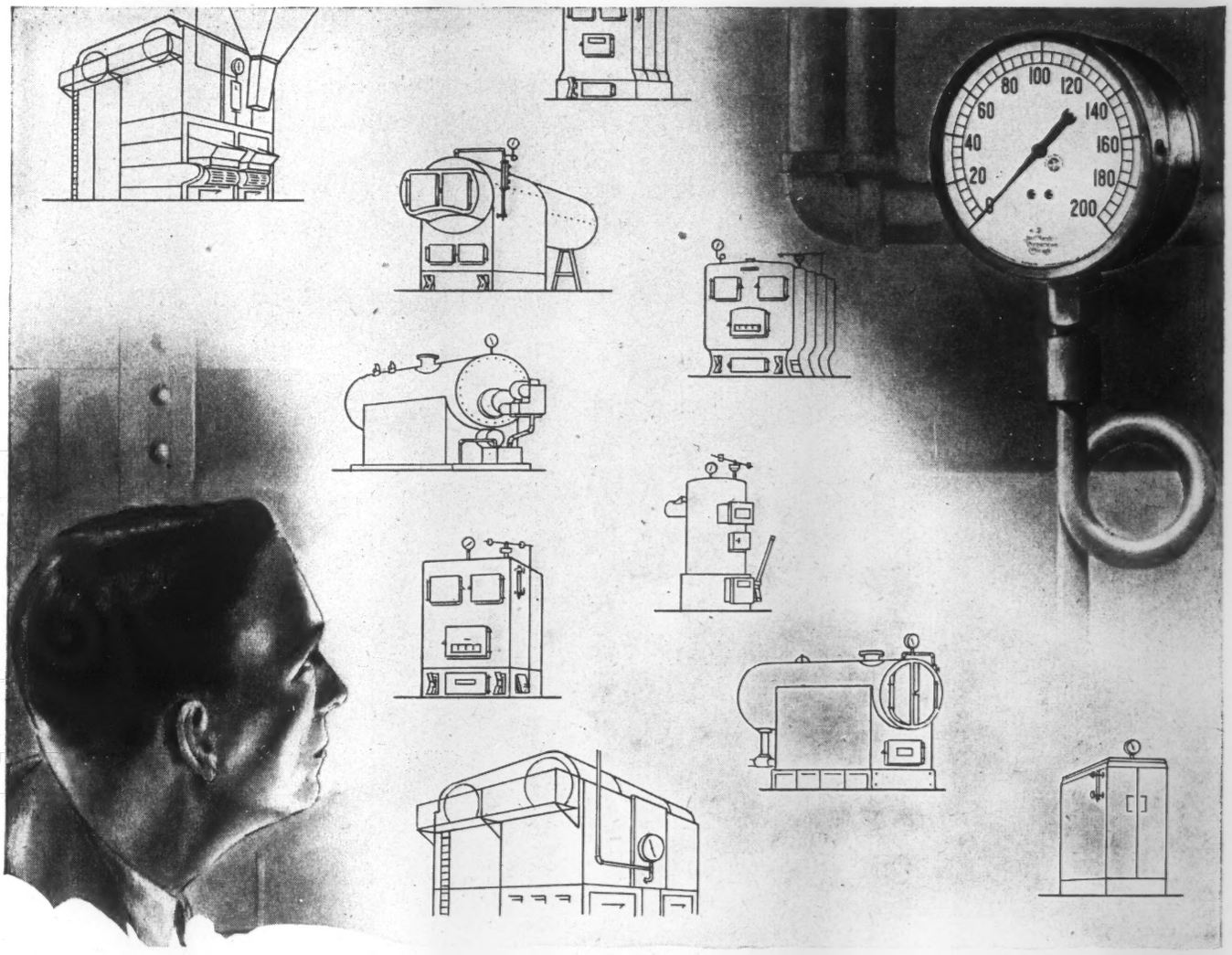



**Originators of KANTLINK the long-range spring washer**

**THE NATIONAL LOCK WASHER COMPANY**

Newark 5, New Jersey — Milwaukee 2, Wisconsin




# . . . *Way out in front in the boiler field*

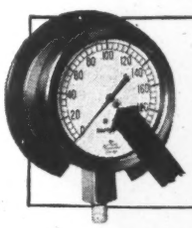
● Yes, a large majority of boiler manufacturers use Marsh pressure gauges. Marsh is out in front in every branch of this big industry—low pressure, high pressure, cast iron, fire tube, self-contained, water tube—from the smallest up to the largest.

In current trade directories, more than 65% of the boiler manufacturers listed equip their product with Marsh Gauges; and while actual boiler production figures are not available, this particular 65% of the boiler manufacturers unquestionably do, by the most conservative estimate, over 80% of the world's boiler business!

Here is a remarkable tribute to the lasting accuracy of Marsh instruments by men who use gauges in large quantities—men who know pressure gauges forward and backward. Yet it is only one example of the preference shown in many fields by manufacturers of products in which accurate pressure indication is vital.*

Keep this in mind when you buy pressure gauges. Use the instruments that are preferred by the most discriminative users of pressure gauges . . . *Marsh.*

**Jas. P. Marsh products include:** A full line and range of gauges in pressure, compound, altitude, hydraulic, sprinkler, ammonia, ounce-graduated retard, test, and diaphragm types. Dial thermometers in rigid stem and remote reading types. A broad line of steam and hot water heating specialties. Ask for literature.



**MARSH ALONE HAS THE "RECALIBRATOR" —quickest and best way to correct a gauge that has been knocked out of adjustment by improper handling.**

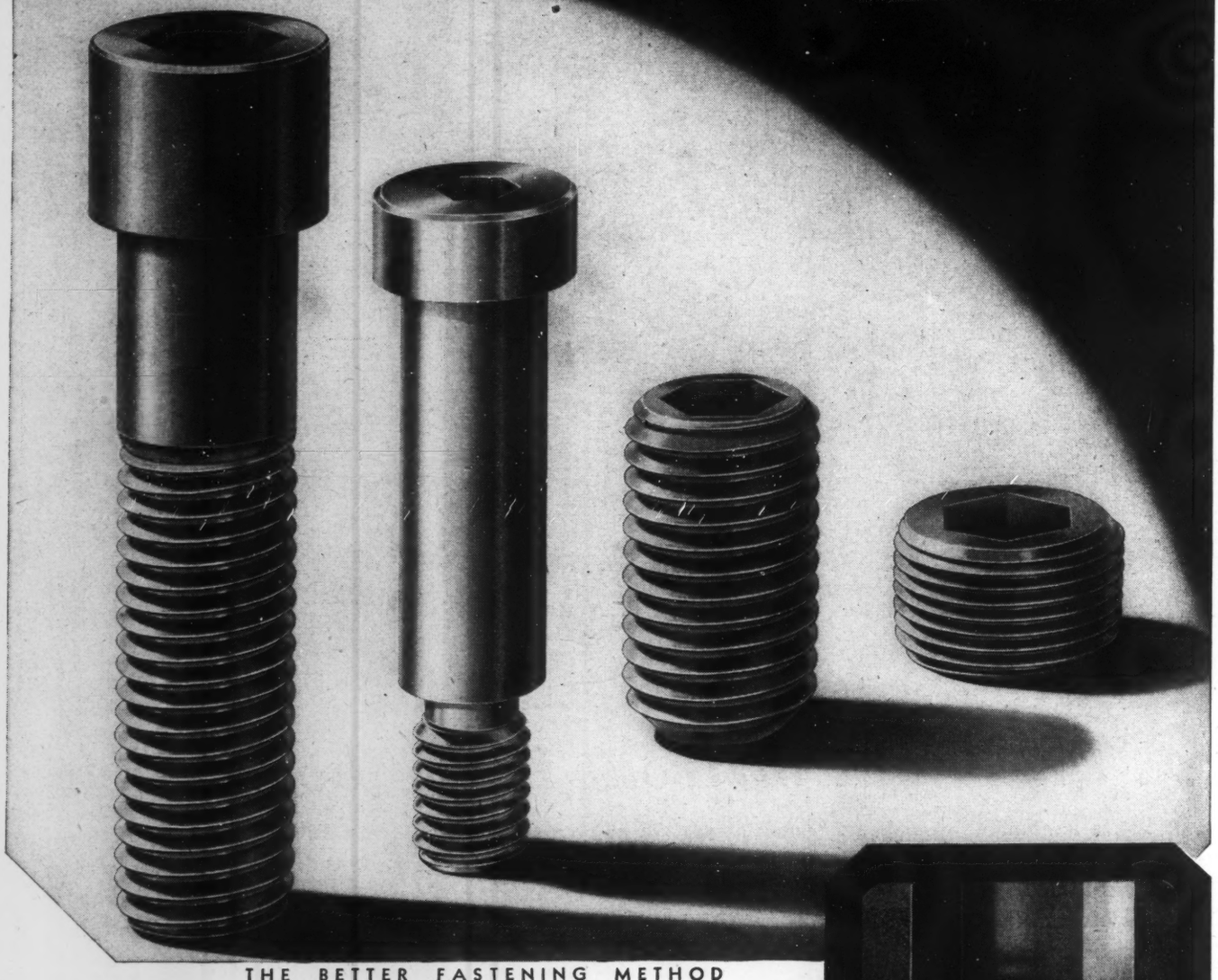
**JAS. P. MARSH CORPORATION**
**2039 Southport Avenue, Chicago 14, Illinois**

# MARSH GAUGES

**"THE STANDARD OF ACCURACY"**

*** Subsequent advertisements will cite additional examples of this.**

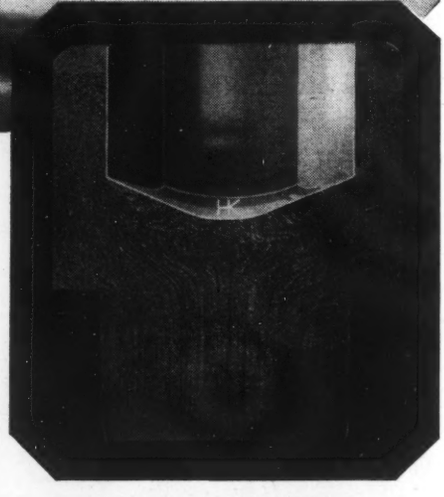
# HOLO-KROME *fibro forged* SOCKET SCREWS



THE BETTER FASTENING METHOD

## Unseen Quality makes them stronger!

**It's the uninterrupted, unbroken and unsevered fibrous structure accomplished exclusively by the Holo-Krome patented method of Completely Cold Forging . . . The results of this exclusive Holo-Krome feature is giving thousands upon thousands of Socket Screw users guaranteed unfailing performance in all types of applications - - - Specify "Holo-Krome".**



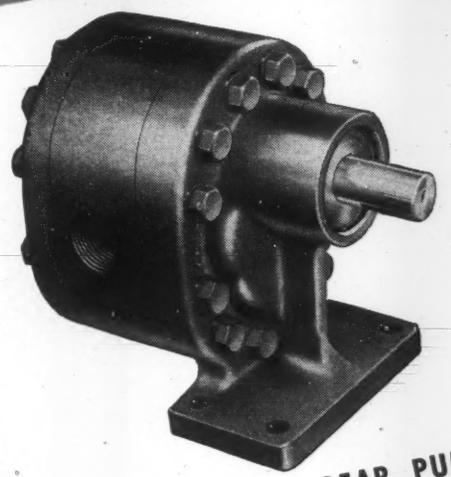
*Unretouched Photo Etched, Cutaway Holo-Krome Socket Head Cap Screw.*

YOUR HOLO-KROME INDUSTRIAL DISTRIBUTOR IS READY TO SERVE YOU FROM HIS WAREHOUSE STOCK

THE HOLO-KROME SCREW CORPORATION
HARTFORD 10, CONNECTICUT

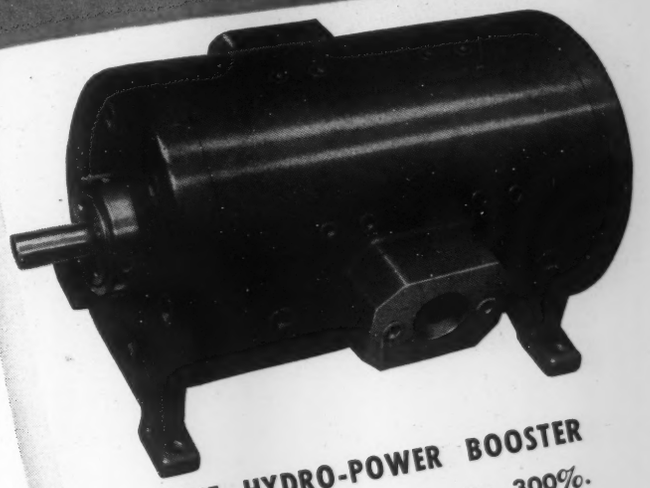
# *Two Space-Saving Units*

## FOR HYDRAULIC POWER SYSTEMS



**THE *Cubline* GEAR PUMP**

Three sizes . . . Capacities of 10-15-20 gallons per minute.



**THE HYDRO-POWER BOOSTER**

Increases pump capacity 300%.

Whether you are using hydraulic power now or considering it for future applications, you should have all the details about these two Hydro-Power-designed units.

**NEW GEAR PUMP.** This new pump was designed to give you three things: first, a compact, space-saving unit that will let you apply hydraulic power where space is at a premium; second, a versatile pump, fitting a multiplicity of different applications; third, a sturdy, precision-built unit that can withstand tough service at a price that removes cost objections.

**NEW HYDRO-POWER BOOSTER.** This is the working partner of the Hydro-Power Pump. With the Hydro-Power Booster you can get three times the rated pump pressure—step up your 1,000 pound pressure to 3,000 pounds. The Hydro-Power Booster can be used with any pump. All you need do is valve the pump discharge through the Booster and up goes your pressure. With the Hydro-Power Booster, ram diameters in newly designed machinery can be reduced to ⅓rd previous areas.

These two units open up entirely new fields for the application of hydraulic power. For more complete information about the new Hydro-Power Gear Pump and Power Booster, mail the handy coupon.

**HYDRO-POWER, INC.**

Belmont and Sheridan Aves. · Springfield, Ohio

***Recommended For:***

- Concrete Block-Making Machinery
- Steel Mill Equipment
- Road Grading Equipment
- Dump Trucks
- Airplanes
- Bulldozers
- Extrusion Machines
- Oil Extraction Machinery
- Snow Plows
- Scarifiers
- Material Handling Equipment
- Baling Machines
- Plastics Molding Machinery
- Die Casting Machinery
- Heavy-Duty Jacks

and many others

hydro power

*hydraulics*

FOR DEPENDABLE PACKAGED POWER

Hydro-Power, Inc.
Belmont and Sheridan Aves.
Springfield, Ohio

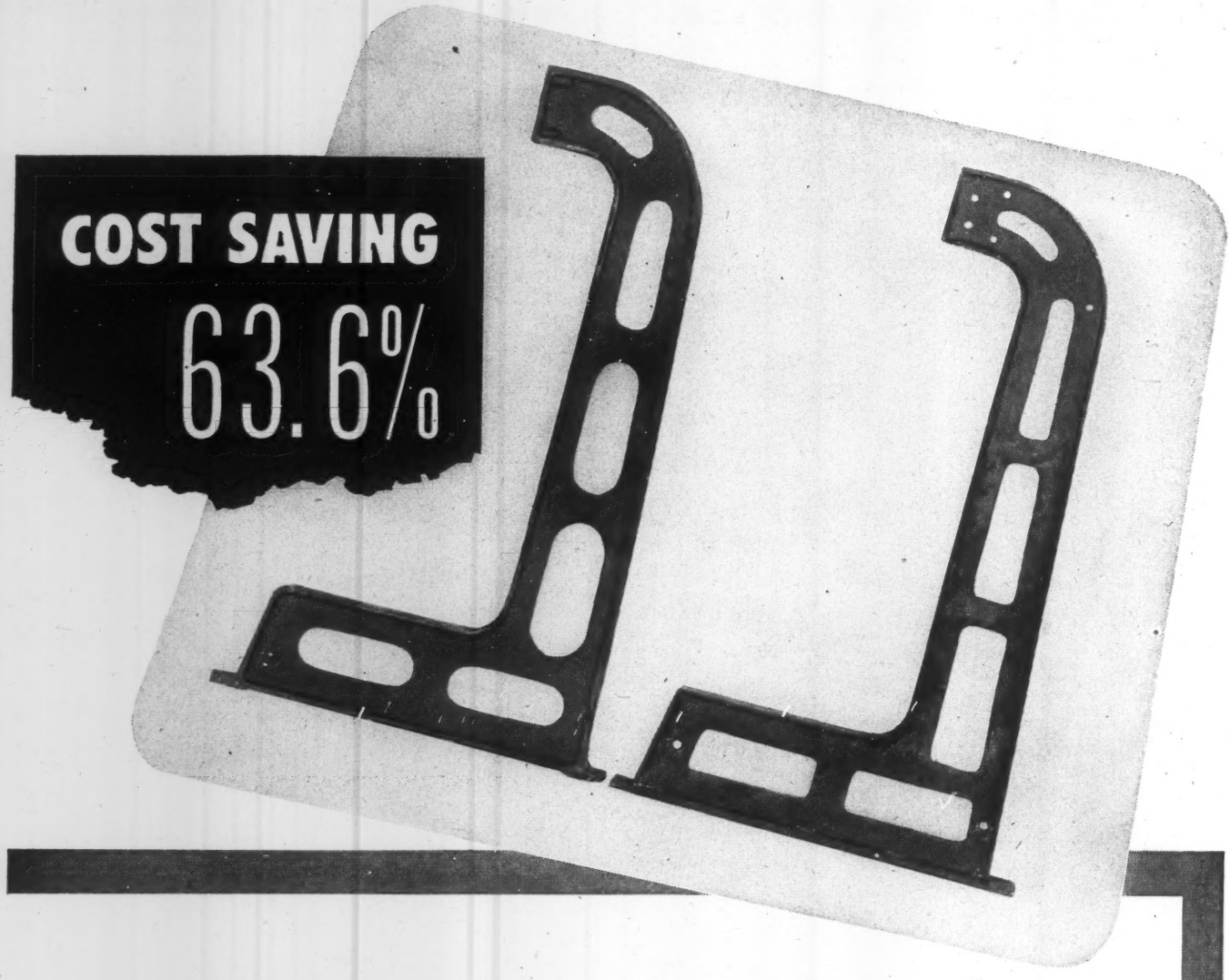
Please send me additional information about your new Cubline Gear Pump and Power Booster.

Name_____ Title_____

Company_____

Street_____

City and Zone_____ State_____




Steel castings engineers are practical people. They know that neither the casting process nor any other process always has the answer when it comes to producing quality steel parts economically.

But there are many instances in industry where casting does afford big savings in production costs, often with greater strength and ability to perform.

The fabricated saw frame (right, above) was a perfectly satisfactory part. It did its job well.

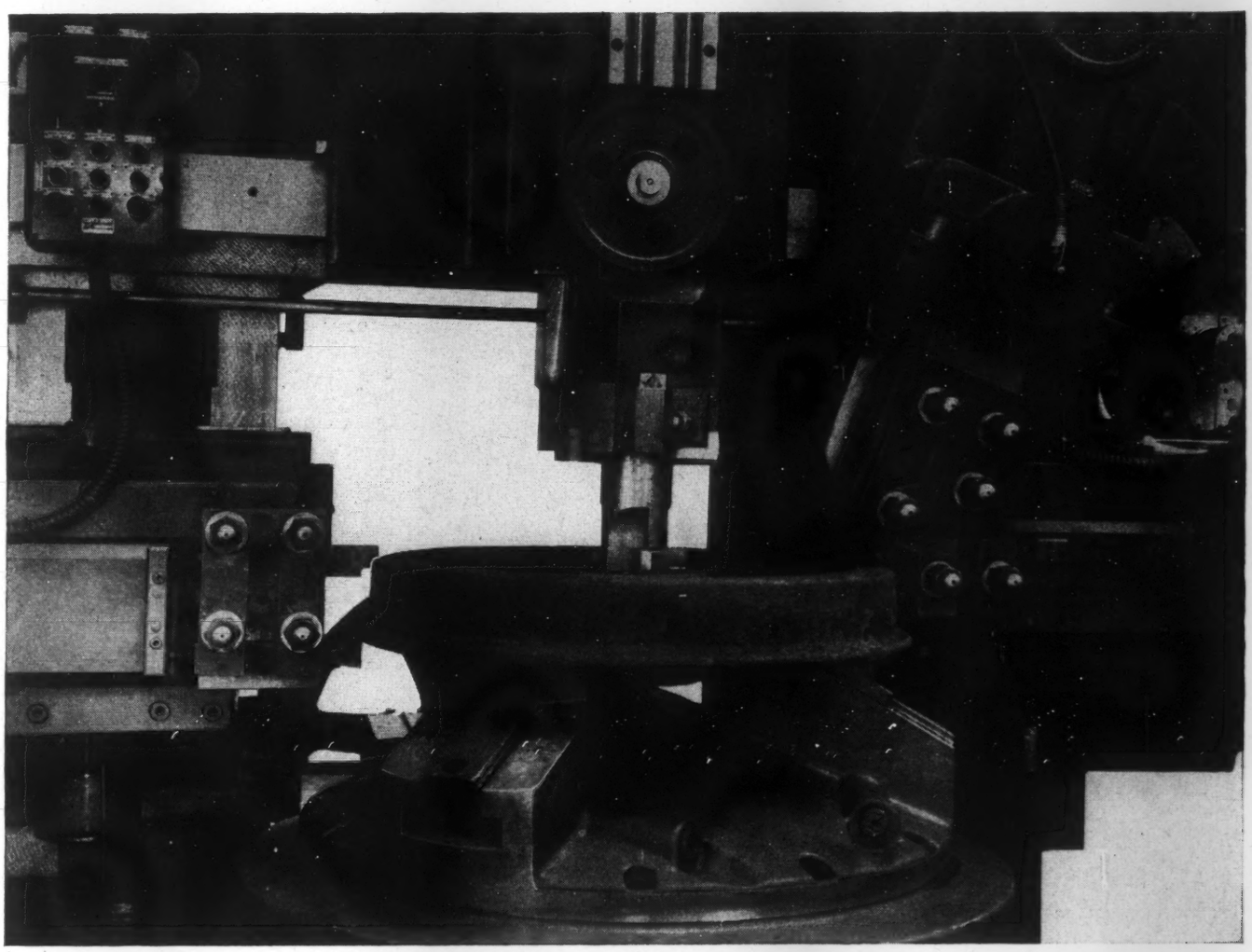
Then the one-piece cast part (left, above) was designed. It did the job equally well, yet it cost 63.6% less to make.

Steel castings do not always show savings like that, but they do it often enough to make the subject worth investigating.

The first step in building an improved product, or in cutting costs, is to plan it that way—a steel castings engineer can help you. Steel Founders' Society, 920 Midland Building, Cleveland 15, O.

MODERNIZE AND IMPROVE YOUR PRODUCT WITH

# STEEL CASTINGS



# *New* TIMKEN BEARING EQUIPPED Machine Revolutionizes Railroad Car Wheel Finishing

Thanks to this remarkable postwar development of the Cincinnati Planer Company, Cincinnati, Ohio, rolled steel car wheels now can be completely machined at the rate of approximately six wheels per hour — a considerable reduction in production time and cost.

An ingenious new chucking device assures quicker setting and accurate centering of the wheel and permits boring of the center hole simultaneously with the machining of the rim, flange and tread, resulting in a better balanced, better finished wheel.

Prominent among the provisions for precision, dependability, endurance and low maintenance are 19 Timken Tapered Roller Bearings applied on the input shaft, bevel gear shaft, table drive shaft, clutch shaft, spindle, rail head pinion and rail drive idler.

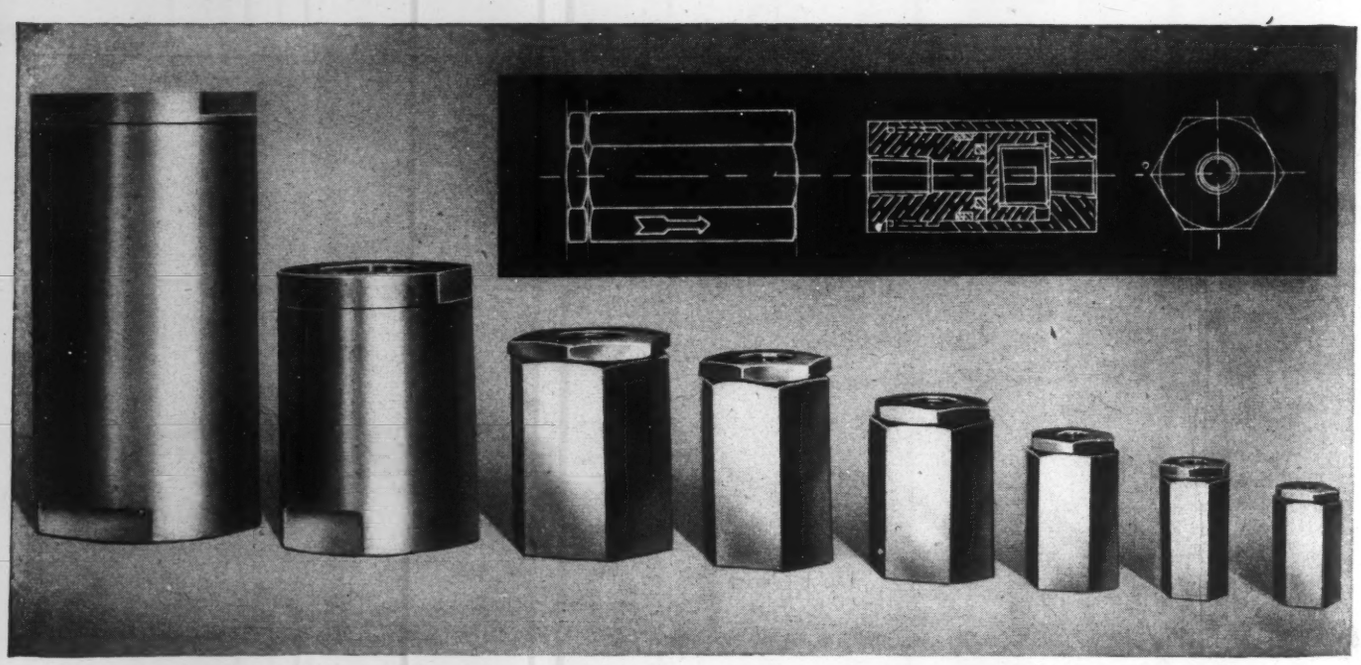
Any machine is a better machine when it is Timken Bearing Equipped, as thousands of manufacturers and users have proved. Look for the trade-mark "TIMKEN" on every bearing that goes in your equipment. The Timken Roller Bearing Company, Canton 6, Ohio.

**TIMKEN**

TRADE-MARK REG. U. S. PAT. OFF.

**TAPERED ROLLER BEARINGS**

**48 YEARS OF ENGINEERING AND METALLURGICAL DEVELOPMENT**



Made in 10 pipe sizes—⅛", ¼", ⅜", ½", ¾", 1", 1¼", 1½", 2" and 3". Stock sizes immediately available. Other sizes to your specifications.

# ELECTROL'S CHECK VALVES

**ALL ELECTROL CHECK VALVES are designed for *rugged service, long life* and *positive sealing* from *low* to *high* pressures.**

**ALL ELECTROL CHECK VALVES are *low* in cost, *economical* in operation and *efficient* in service. Standard models feature brass and bronze elements.**

**Other models are made of steel or metals best suited to the service required.**

**ALL ELECTROL CHECK VALVES provide air, gas, water and oil control lines with a minimum pressure drop and positive sealing against return flow. They are successfully used in a wide variety of industrial installations, and in the hydraulic or pneumatic systems on busses, trucks, railroads, boats, aircraft, farm, road and shop machinery, power and plastic presses, blue print machines and soda fountains.**

**WHEREVER THERE IS FLOW THERE IS A PLACE FOR AN ELECTROL CHECK VALVE.**

***For better results from your hydraulic control system, write ELECTROL today.***

**CYLINDERS • SELECTOR VALVES • FOLLOW UP VALVES**
**CHECK VALVES • RELIEF VALVES • HAND PUMPS**
**POWERPAKS • OLEO STRUTS • SOLENOID VALVES**
**ON-OFF VALVES • SERVO CYLINDERS • TRANSFER VALVES**
**CUT-OUT VALVES • SPEED CONTROL VALVES**

**ELECTROL** *INCORPORATED*

***FOR BETTER HYDRAULIC DEVICES***

***KINGSTON, NEW YORK***

*THE DOCTOR SAYS IT'S*

# "Industrial Arteriosclerosis"

What the Doctor means, of course, is "thickening of the walls of the arteries"—the rust-clogging of those all-important industrial pipelines that convey water, compressed air, gases, fuel oil, refrigerants, lubricants, and an almost endless variety of process materials in fluid form.

Symptoms may be evident in reduced volume of flow, inadequate pressure, increased pumping costs, or rust-stained solutions.

Surface coatings of any kind offer but temporary protection and, eventually, rust-roughened pipe interiors will accelerate "sliming-up," particularly in lines with threaded fittings. The result may be a product contaminated by flaked-off scale, non-seating valves, clogged indicating or recording instruments, untimely dismantling for cleaning, or premature pipe replacement.

Copper tubes are not a panacea for all industrial piping ills—but they go a long, long way toward a permanent cure. Just how and why are explained on the following page.

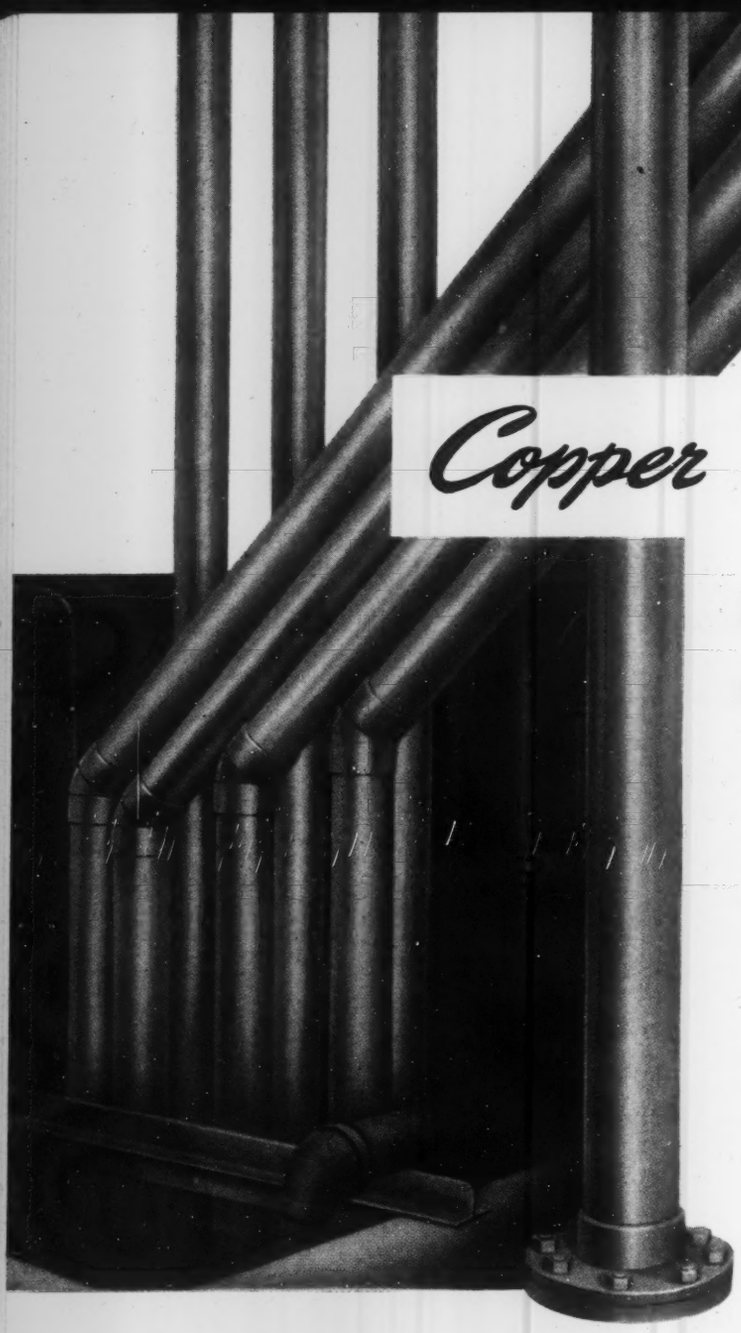
**THE AMERICAN BRASS COMPANY**

*General Offices:* Waterbury 88, Connecticut

ANACONDA

from mine to consumer

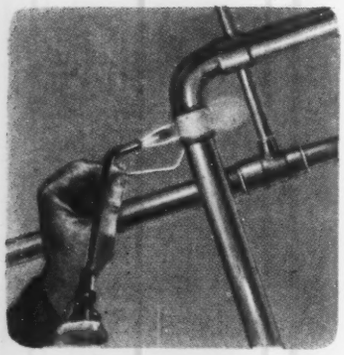
*Anaconda* **COPPER TUBES AND FITTINGS**



# *Copper Tube Pipelines?*

## COMPARE THEM—point for point with any material . . . at any price

- Copper tubes combine the advantages of corrosion resistance, light weight, flexibility and low installation costs.
- Pipelines of copper tubes connected with solder fittings can be taken down, moved, or have new connections cut in faster and with less expense than with threaded pipe.
- Bends and offsets to clear beams, girders or other obstructions can be made readily in copper tubes.
- Assembled with solder fittings, such lines have a low coefficient of friction and reduced resistance to flow . . . no need for oversize lines to provide for clogging.
- Anaconda Solder Type Fittings can be installed in restricted space where the use of a wrench would be impossible.
- Anaconda Copper Tubes in standard sizes are furnished to A.S.T.M. and Federal Specifications: Soft in 60-ft. coils; also hard and soft in 20-ft. straight lengths from ⅜″ to 12″ in diameter. Larger sizes, up to 26″ I.D., can be made to order.



*Publication C-24 tells a lot more about Anaconda Copper Tubes and Fittings. A copy will be mailed on request.*

**THE AMERICAN BRASS COMPANY**

General Offices: Waterbury 88, Connecticut

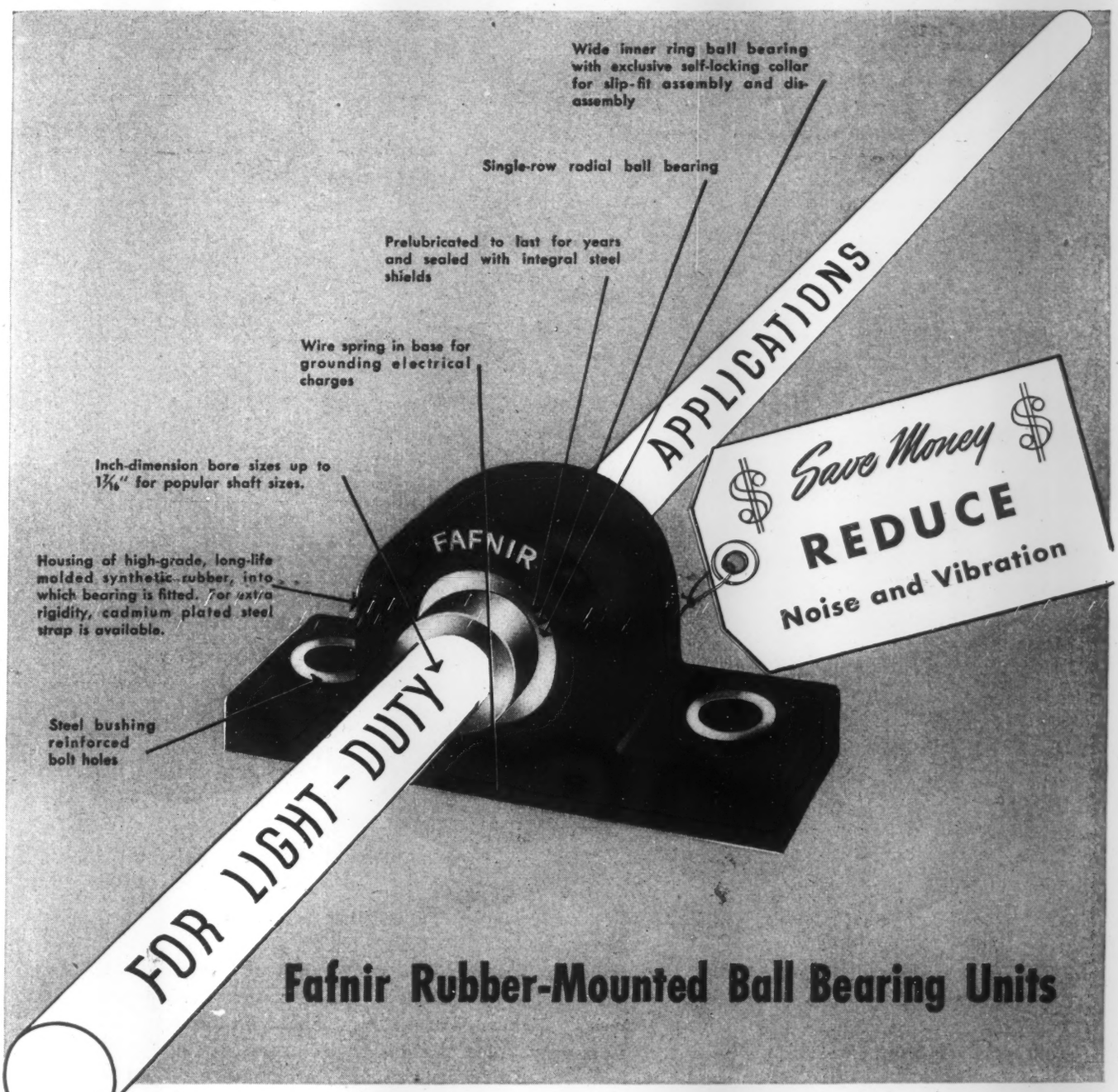
*Subsidiary of Anaconda Copper Mining Company*

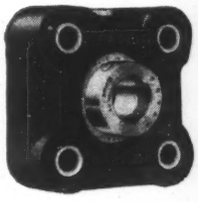
*In Canada: Anaconda American Brass Ltd., New Toronto, Ont.*

46162

ANACONDA
from mine to consumer

# *Anaconda* COPPER TUBES and FITTINGS



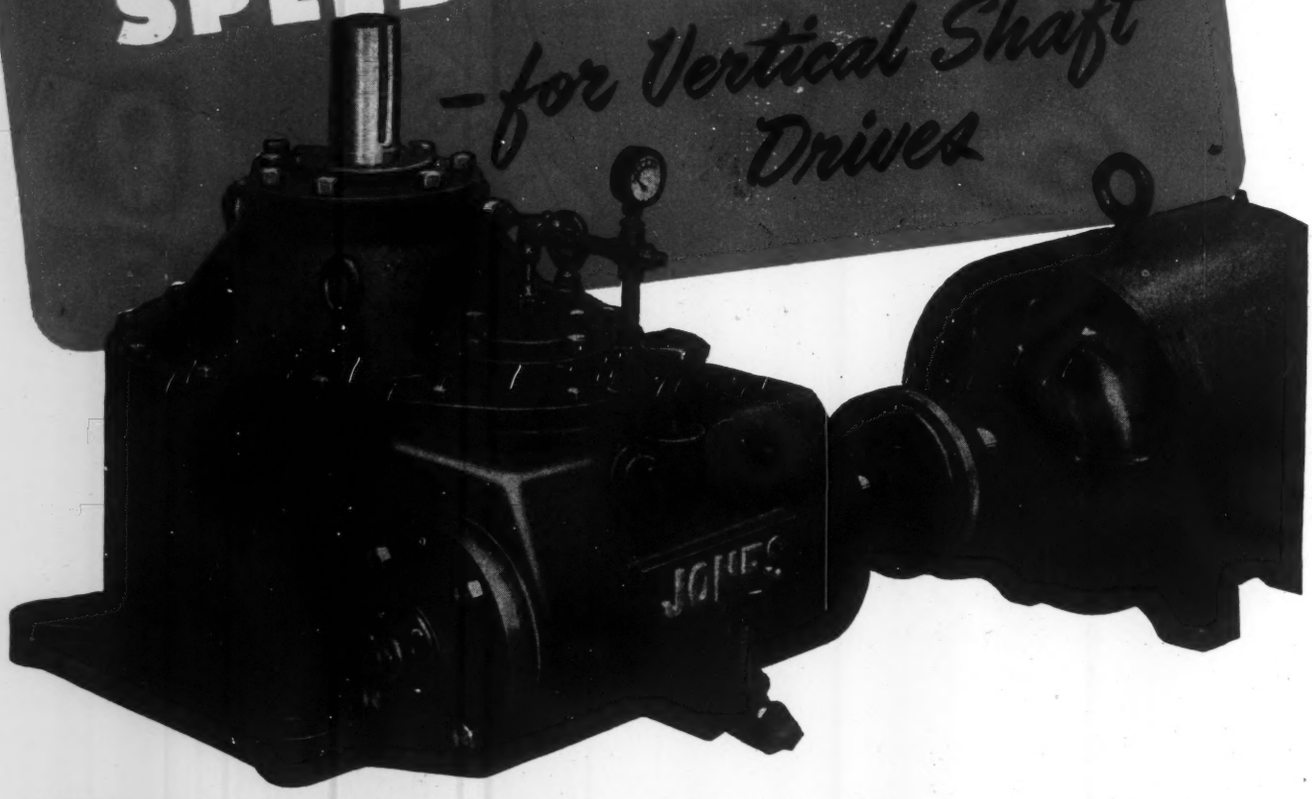
*. . . also rubber mounted flange and cylindrical cartridges*

HERE'S A BEARING BARGAIN for manufacturers of small fans, domestic heating, ventilating and air-conditioning equipment, and small conveyor systems. In one economy-priced package you get low starting torque to save motors, up to 10% power saving, automatic lubrication, self-maintenance, and faster, simpler assembly . . . all wrapped up in a noise and vibration absorbing synthetic rubber mounting. It's a competitive advantage for you tagged with a bargain price. Write for descriptive folder showing complete line of rubber-mounted units. The Fafnir Bearing Company, New Britain, Conn.

**MOST COMPLETE LINE IN AMERICA**

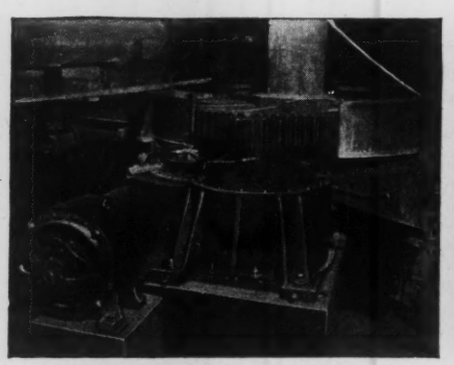
# Jones WORM-HELICAL SPEED REDUCERS

*—for Vertical Shaft Drives*

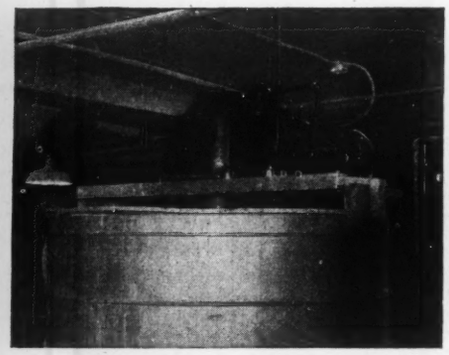



THESE machines fill a long felt need for double reduction units of the fully enclosed type to be used for agitators, mixers, ore roasters, bending rolls, etc., requiring a vertical shaft drive. Built in standard ratios in various types of assemblies ranging from 40 to 1 to 250 to 1 for all common motor speeds and a wide range of horsepower ratings.

Jones Bulletin No. 75 covers complete details on these Worm-Helical Speed Reducers, with rating tables, dimension diagrams, torque charts and other application information. We shall be pleased to send you a copy.



• Jones Worm-Helical Speed Reducer on ore roaster with section of dust guard removed to show final gear reduction.



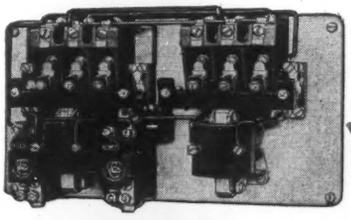
• Jones Worm-Helical Speed Reducer driving a lacquer agitator. A simple design prevents leakage of oil along the vertical low speed shaft.

• Jones Worm-Helical Speed Reducer on a paper mill agitator drive.

**W. A. JONES FOUNDRY & MACHINE CO., 4413 Roosevelt Road, Chicago 24, Illinois**

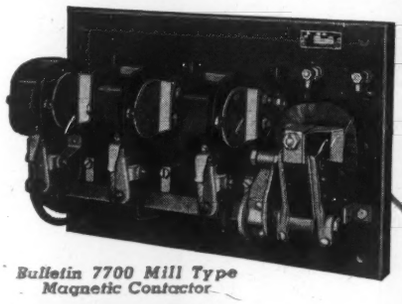
# SPECIALLY DESIGNED MACHINE TOOL CONTROL *built entirely of* STANDARD CONTROL APPARATUS

Six motors on a Vertical Boring Mill are controlled and protected by standard devices. The right devices to provide correct control and protection for the motors were selected by experienced "3C" engineers, and arranged to give proper sequence to each operation.



*Bulletin 6030 Magnetic Reversing Starter*

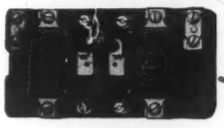
The Motors for Rail Elevating, Rail Head, and Traverse are controlled by Bulletin 6030 Reversing Starters. These provide full voltage reversing through two sturdy Bulletin 7707 Contactors mechanically interlocked to prohibit simultaneous closing of both contacts.



*Bulletin 7700 Mill Type Magnetic Contactor*

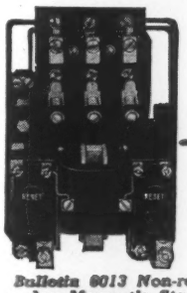
The 30 HP Main Drive Motor is controlled by a Bulletin 7700 Magnetic Contactor.

High speed closing with minimum impact is insured because the light weight hinged armature moves a very short distance in closing the contactor. Duplicate hard drawn copper tips, for both stationary and moving contacts, are kept surface clean by a rolling wiping motion in closing.



*Bulletin 7322 Thermal Overload Relay*

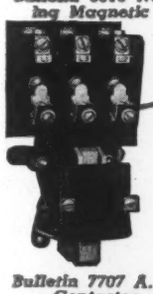
A duplex Mill Type Bulletin 7322 Thermal Overload Relay provides overload protection, giving inverse time protection with delayed trip to permit high starting inrush currents, but will successfully open the pilot circuit when an unsafe overload occurs.



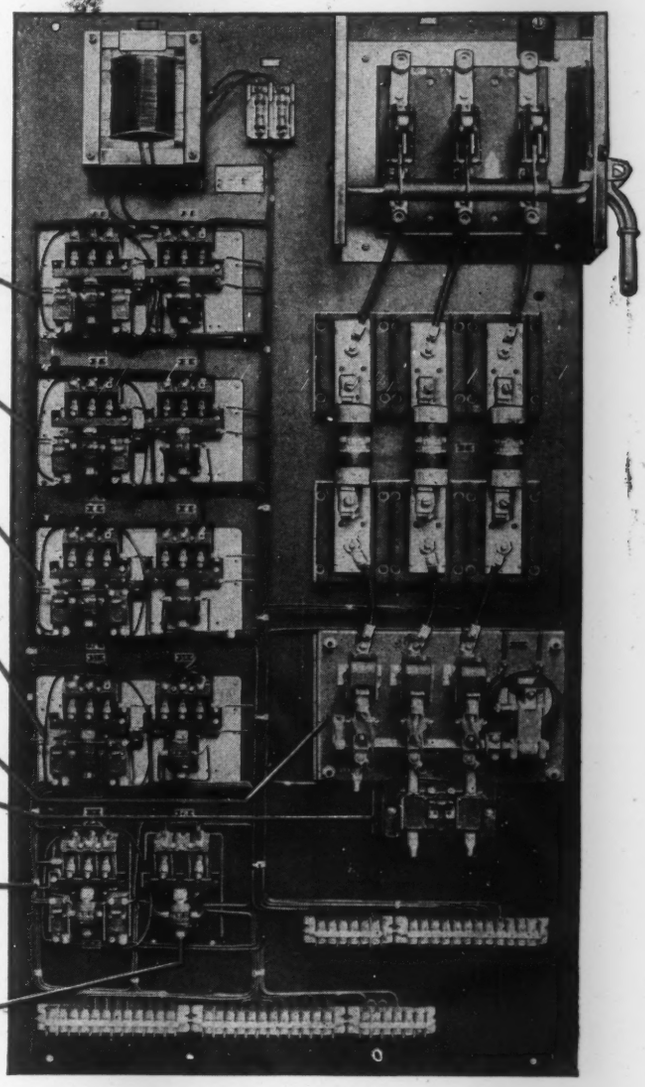
*Bulletin 6013 Non-reversing Magnetic Starter*

The coolant motor is controlled by a Bulletin 6013 Motor Starter, which is comprised of the sturdy, small, compact Bulletin 7707 Contactor, and Bulletin 7323 Thermal Overload Relays.

The Bulletin 7707 Relay is used with the Bulletin 7700 Contactor for running, except at times when inching by Push Button is desired.



*Bulletin 7707 A. C. Contactor*



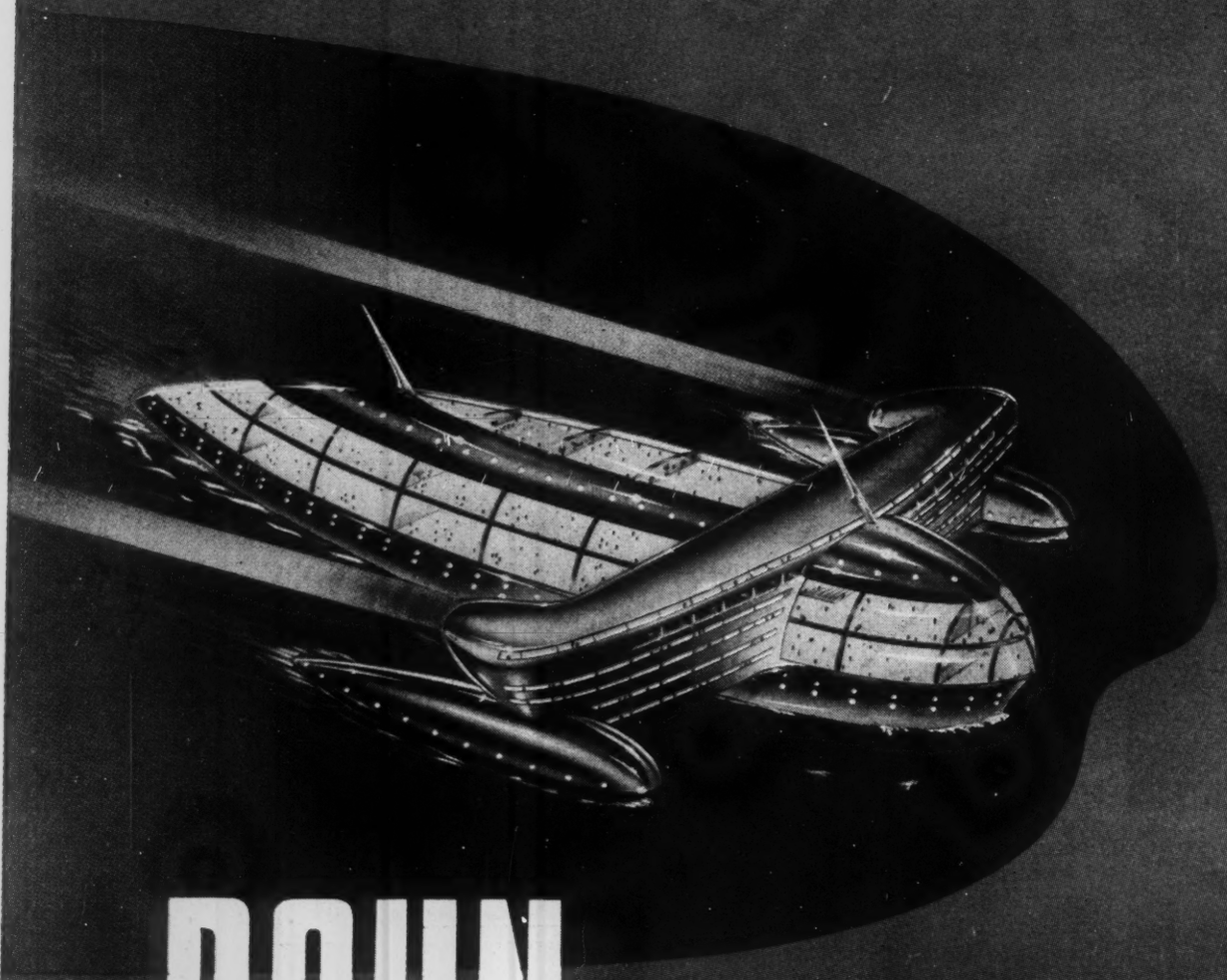
*"3C" Control Panel for Vertical Boring Mill*

The "3C" Engineering knowledge which has provided reliable electrical control using standard apparatus, is at your service in solving machine tool control problems.

**THE CLARK CONTROLLER CO.**

EVERYTHING UNDER CONTROL • 1146 EAST 152nd STREET, CLEVELAND 10, OHIO

# WHEN DREAM SHIPS COME TRUE



# BOHN

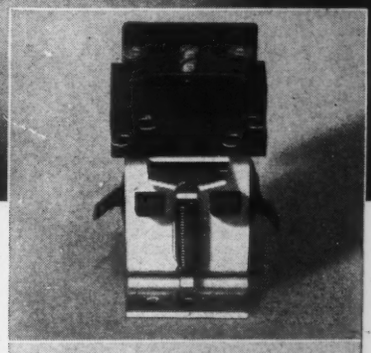
For those who like to take their ocean voyages at high speed but do not wish to relinquish such luxuries as swimming pools, orchestras and sun decks, etc., the following might be a solution. Why not giant jet-propelled ships which could provide the desired comforts and at the same time have the faster speed? Such developments as this and a thousand others call for the use of light alloys—aluminum and magnesium—as produced by the Bohn organization. Bohn engineers and production experts have the "Know-how"—can give expert advice on the many advantages of light alloys. Consult Bohn first.

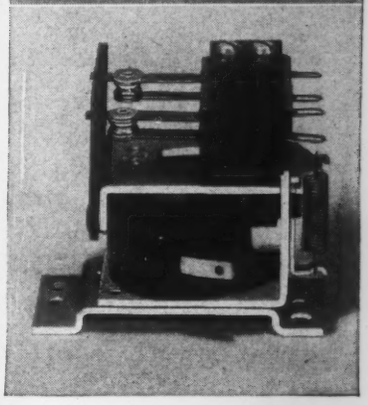
**BOHN ALUMINUM & BRASS CORPORATION**

GENERAL OFFICES—LAFAYETTE BUILDING • DETROIT 26, MICHIGAN

*Designers and Fabricators*—ALUMINUM • MAGNESIUM • BRASS • AIRCRAFT-TYPE BEARINGS

# VERSATILE NEW LINE OF... A·C AND D·C RELAYS





## EXCEPTIONALLY SMALL AND COMPACT YET EXTREMELY RUGGED!

● R-B-M announces a new line of general purpose magnetic relays, with either A.C. or D.C. shunt coils or series coils, for electronic applications.

Relays are available in standard contact arrangement of single and two pole normally open, normally closed; or double throw with light and heavy contacts. Four and six pole double throw relays are available with 3 ampere contacts at 32 volts or less.

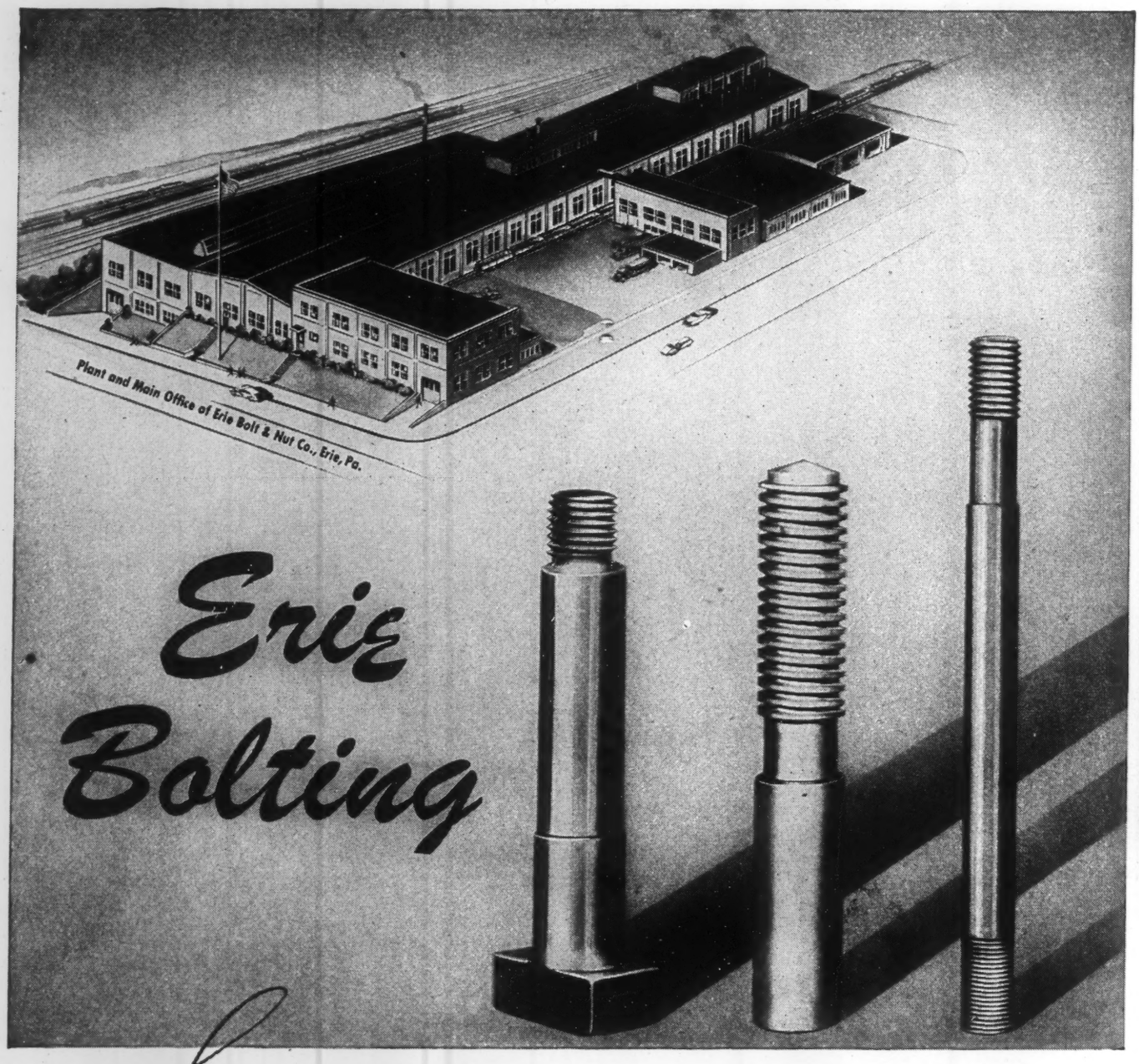
Insert shows two pole, double throw contactor rated 13 amperes, 115 volts, A.C., and 6.5 amperes at 230 volts, A.C. This relay is designed in accordance with Underwriters' specifications and will ultimately carry Underwriters' Approval for Small Devices classification.

For further information write for Bulletin 570. Address Department H-3 . . .

**R-B-M DIVISION**
**ESSEX WIRE CORPORATION**
**Logansport, Indiana**

ALSO

Distributed by GraybaR ELECTRIC COMPANY




*Send* YOUR BOLTING SPECIFICATIONS *to a Specialist*

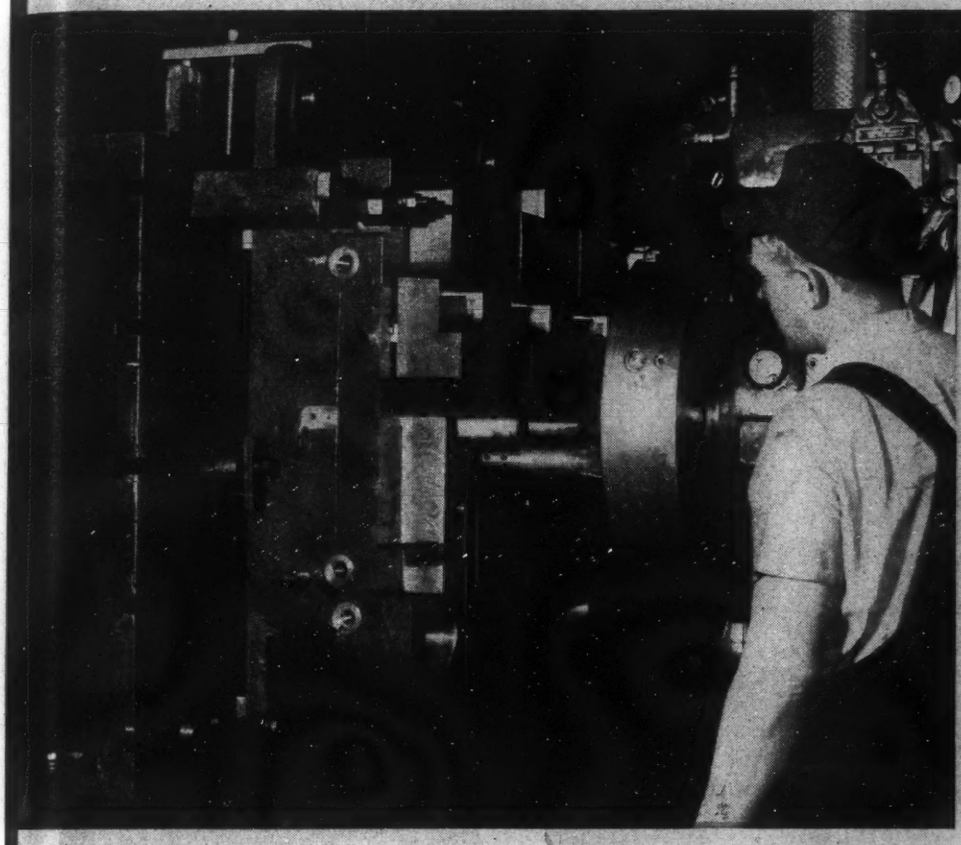
**ERIE BOLT & NUT COMPANY** *for over thirty years has solved thousands of out of the ordinary bolting problems. As a specialist in bolting, we are especially well equipped to manufacture bolts, studs or nuts in sizes, shapes and tolerances required—threading to any desired fit with heat treatment to specification.*

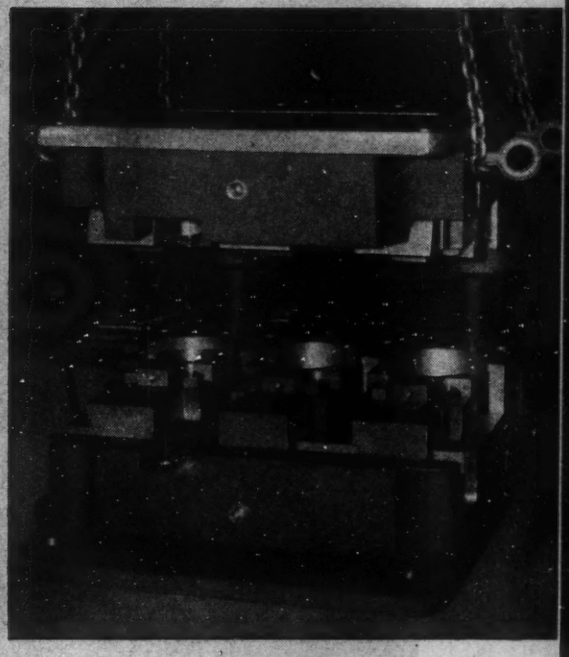
**ERIE BOLT & NUT CO.**

**ERIE, PA.**

STUDS • BOLTS • NUTS ~ ~ ALLOYS • STAINLESS • CARBON • BRONZE

# *Now* Danly Special Die Sets





## *with any additional machining required*

New equipment installed in the Danly shop permits us to do any machine work on large or complex die sets incidental to the mounting of the dies. Inserts, recesses, additional boring, keyways and other machining can be done to the customer's specifications.

Time is saved by this service as work on dies and on the die set can be done at the same time. It permits the die shop or tool room to devote their equipment and man hours to the making of dies. The problem of the handling of big sets, for which the die shop or tool room are not generally equipped to do economically, is also solved by this service.

These special die sets are then delivered ready for the mounting of the dies. Note the size and complexity of the die set shown on this page. This die set—machined at Danly—is an example of the additional machining and service which this company offers.

On your next special die set inquiry include the additional machining work that you wish done at Danly while the die set is being made. The cost of this machining will be shown as a separate item in the quotation.

**DANLY MACHINE SPECIALTIES, INC.**

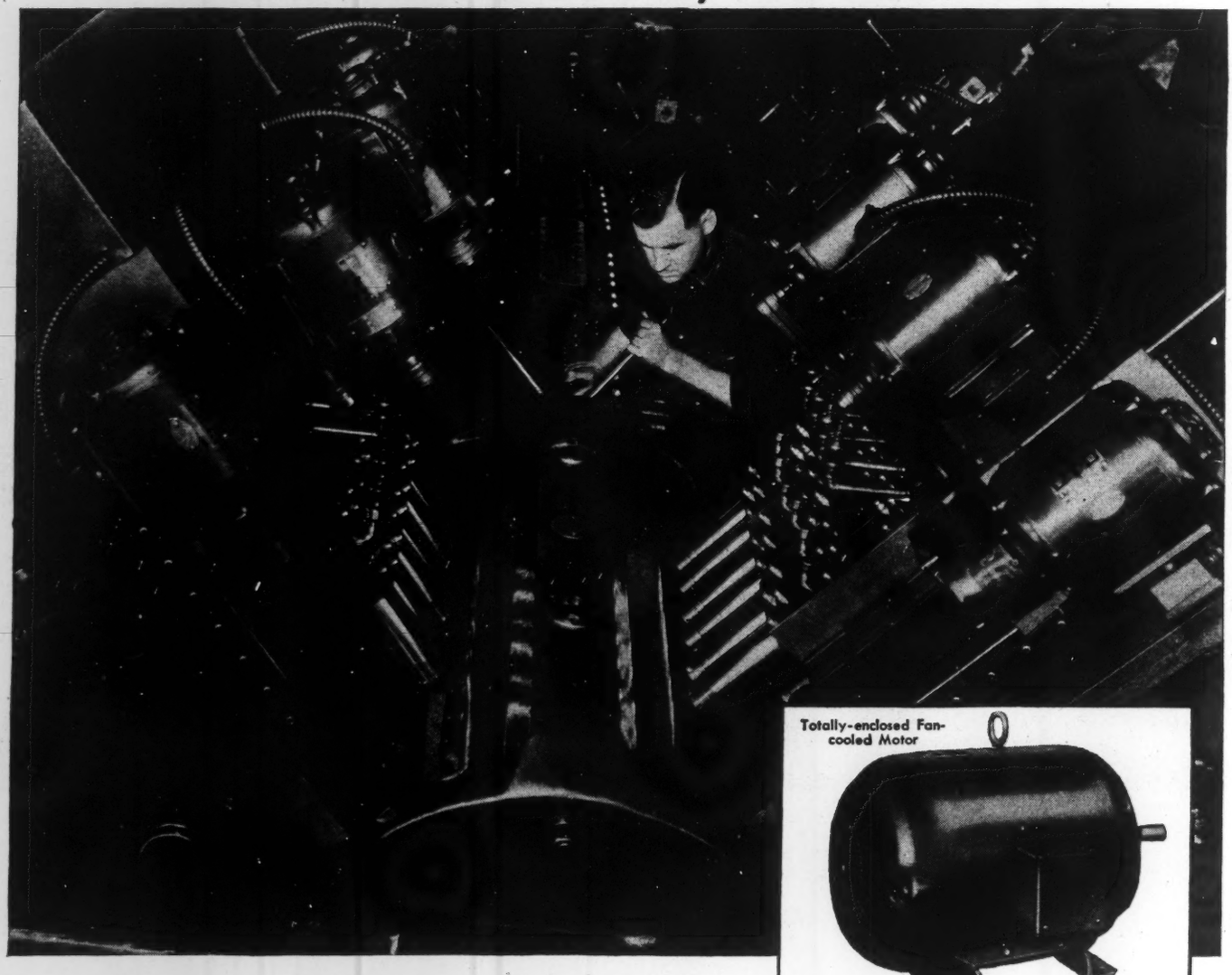
*2100 South 52nd Avenue* • *Chicago 50, Illinois*

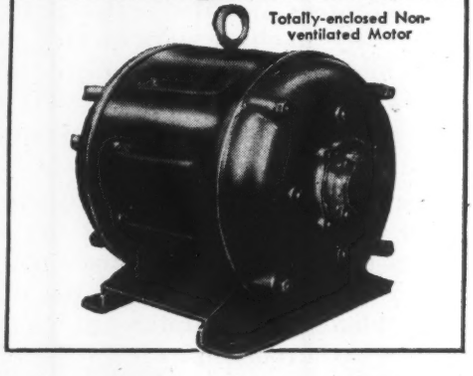
*Milwaukee 2* . . . 111 East Wisconsin
*Detroit 16* . . . . . 1549 Temple Avenue
*Cleveland 14* . . 1550 East 33rd Street
*Dayton 2* . . . . . 990 East Monument
*Rochester 4* . . . 16 Commercial Street
*Philadelphia 44* . . 18 W. Chelten Ave.
*Long Island City 1* . 47-28 37th Street
*Ducommun Metals & Supply Company*
4890 South Alameda, Los Angeles 54

# DANLY *Special* DIE SETS

MACHINED TO YOUR SPECIFICATIONS

# *Machine Tool Manufacturers rely on* WAGNER *Quality* MOTORS





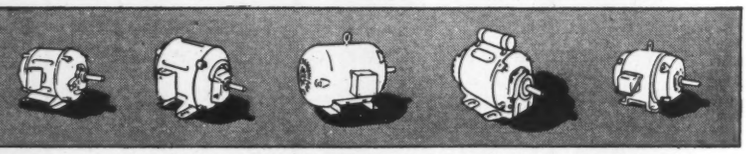

## . . . *for utmost Precision* - -

Yes Sir, he's right in the middle. His job demands utmost precision—and on machine tools such as this, precision is what counts. Wagner Motors have an enviable reputation for quiet, smooth, vibrationless performance. That's why machine tool manufacturers use thousands of Wagner Motors. They have found that Wagner is a synonym for reliability and that every motor bearing this famous name will deliver dependable, troublefree service. Users of Wagner motors also profit by our quick, convenient, nationwide service facilities.

If you want motors that will do the job, whether large or small, contact any of our twenty-nine branches. They are located in principal cities and manned by trained field engineers who will help you solve your motor problems. A letter addressed to Wagner Electric Corporation, 6404 Plymouth Avenue, St. Louis 14, Mo., will bring Bulletins on the complete line of Wagner Quality Motors.

*Consult Wagner Engineers on all Electric Motor Problems*

Wagner Electric Corporation EST. WE 1891



M47-6

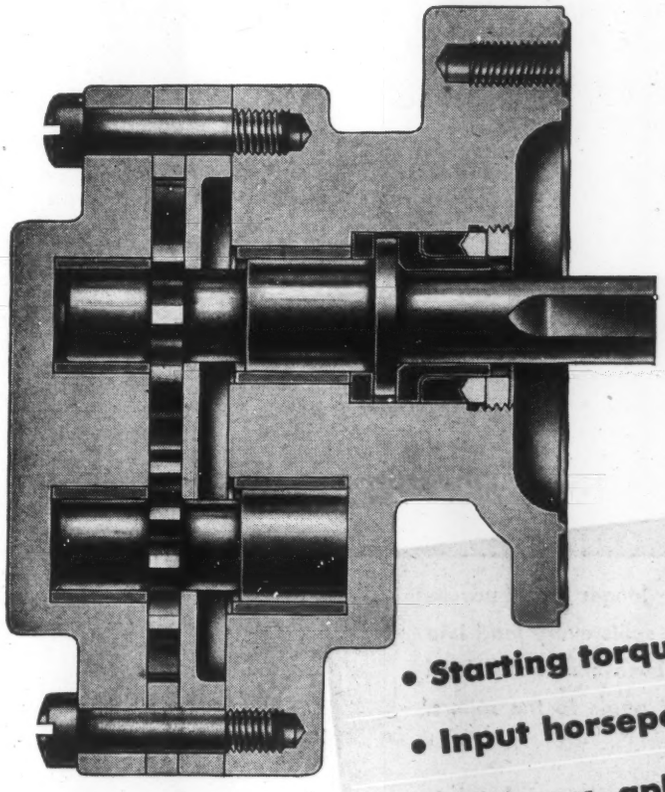
• ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE PRODUCTS •

# Case History of

# FLOW-MASTER "Victor"

## PERFORMANCE

One equipment manufacturer submitted the following data after thorough tests of the FLOW-MASTER "Victor" Pump.*



Flow-Master "Victor" Sectional View, Actual Size Capacity 3-500 gph. Displacement to suit your requirements.

- **Starting torque, once-feet, 10.2.**
- **Input horsepower, .123.**
- **Delivery, gph., 66.0.**
- **Volumetric efficiency, 71.0%.**
- **Overall efficiency, 50.6%.**
- **No starting motor capacitors required.**

* at 100 psi, 1740 rpm.

Performance like this makes the FLOW-MASTER "Victor" the finest small pump for hydraulics, metering, proportioning, transferring.

"Victor" features include the fact that it requires no added lubrication, it has hydraulically balanced rotors to eliminate severe metal-to-metal contact, it automatically compensates for normal wear, it is easy to install.

Marco Catalog No. 25E has complete details, engineering data, prices. Send for a copy.

***FLOW-MASTER*** **Pumps—Homogenizers**
**Kom-Bi-Nators**
**Equipment For The Process Industries**

**MARCO COMPANY Inc. Wilmington 50, Del.**

# YOUR DOLLAR BUYS LONGER SERVICE IN

## ROLLWAY

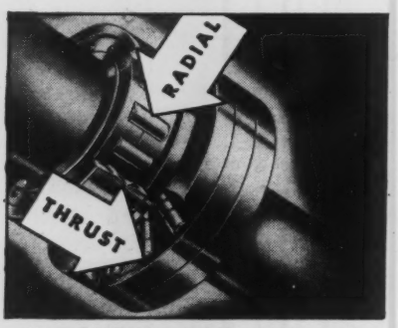
RIGHT-ANGLE-LOADED

## BEARINGS

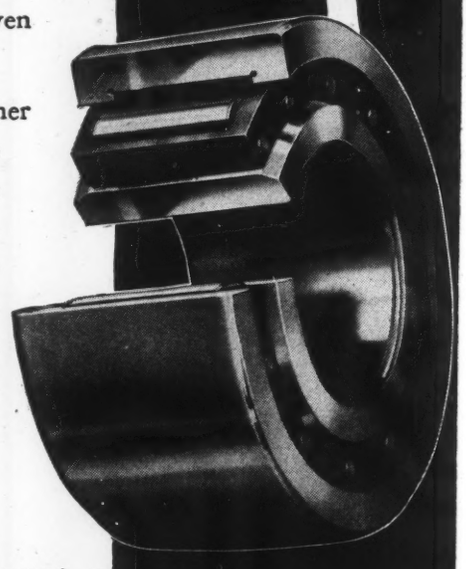
***ROLLWAY's*** Right-Angle-Loaded Bearings have longer life because Rollway uses the principle of *right angle loading*. This splits every load into its component parts of pure radial and pure thrust. Each component load is carried on a separate bearing assembly at a *right angle to the rollers.*

***For this reason,*** Rollway Bearings can use efficiently solid cylindrical rollers of greater mass and cross section area in a given space. The unit load per roller is lower and the load capacity for a given dimensional limit is higher.

As the diagram shows, no oblique loads or resultants, no other compound loads can pile up to increase the magnitude of the simple radial or thrust component. Resistance to shock and vibration is increased. Pinch-out of rollers is eliminated—with less rubbing friction and less wear-back of roller ends. The net gain is clearly apparent in longer bearing life . . . less service attention . . . and lower maintenance cost.




**All radial loads carried at right angles to the roller axis. All thrust loads carried at right angles to the roller axis.**



*Free Service* ***Send us your plans today for engineering analysis and recommendations.***

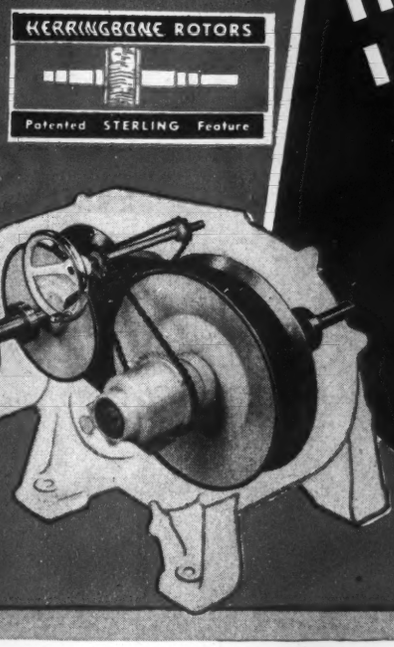
# ROLLWAY BEARINGS

ROLLWAY BEARING COMPANY, INC., SYRACUSE, N. Y.

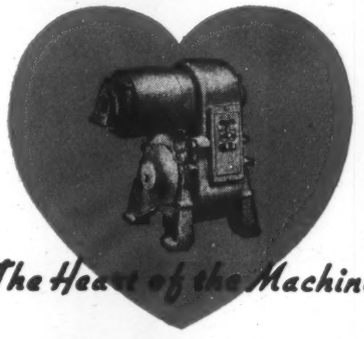
**SALES OFFICES: Philadelphia • Boston • Pittsburgh • Cleveland • Detroit • Chicago • Minneapolis • Houston • Los Angeles**

# STERLING SPEED-TROL GIVES YOU SPEED CONTROL

Increase Production
Improve Quality
with this
*built-in*
VARIABLE
SPEED POWER




**STERLING SPEED-TROL MOTORS**



*The Heart of the Machine*

***A revolutionary design of infinite variable speed, varying from 2:1 to 6:1. ¼ to 15 H.P.***

Sterling System Speed-Trol Units are compact, enclosed, self-contained, infinitely variable speed power units of lasting efficiency, incorporating thoroughly tried and proven principles.

Sterling Speed-Trol Motors make available a greatly improved and inexpensive system of machine drive for all industries—will increase production — improve products — decrease production costs — are revolutionary in their simplicity, and possess features long needed but heretofore never obtainable.

Write for complete information.

**STERLING ELECTRIC MOTORS, INC.**
NEW YORK • CHICAGO • LOS ANGELES
REPRESENTATIVES IN PRINCIPAL CITIES

# STERLING ELECTRIC MOTORS

*for Greater Perform-ability* (sm)

# Heliarc WELDING

## *A fast, easy way to join*

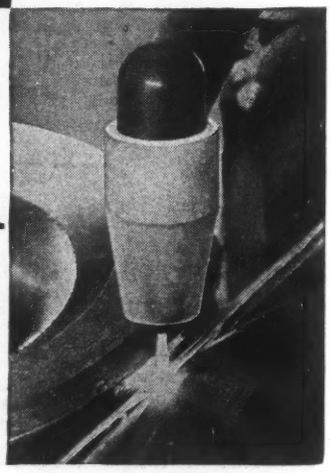
- STAINLESS STEEL
- HIGH-CARBON STEEL
- ALUMINUM
- MAGNESIUM
- BRASS
- COPPER
- EVERDUR
- MONEL
- INCONEL
- SILVER

Linde's HELIARC process is a new and different method of welding with the electric arc, in which the welding action is shielded by an inert gas—usually argon.

Joints welded with the HELIARC process have exceptionally high quality. They are clean because HELIARC welding eliminates flux. Joints are so smooth, even, and neat that usually no finishing treatment of any kind is required.

Butt, lap, tee, corner, and angle joints are easily made on rolled, cast, extruded, or forged parts of stainless steel and practically all non-ferrous alloys of any commercially used thickness.

HELIARC welding can be done manually or with machines and is equally practical for mass production or job lots.



Linde service engineers are always available to help with problems of treating, cutting, joining, and forming metals.

Call or write any Linde office for information.

The word "Heliarc" is a trade-mark of The Linde Air Products Company.

---

THE LINDE AIR PRODUCTS COMPANY

*Unit of Union Carbide and Carbon Corporation*

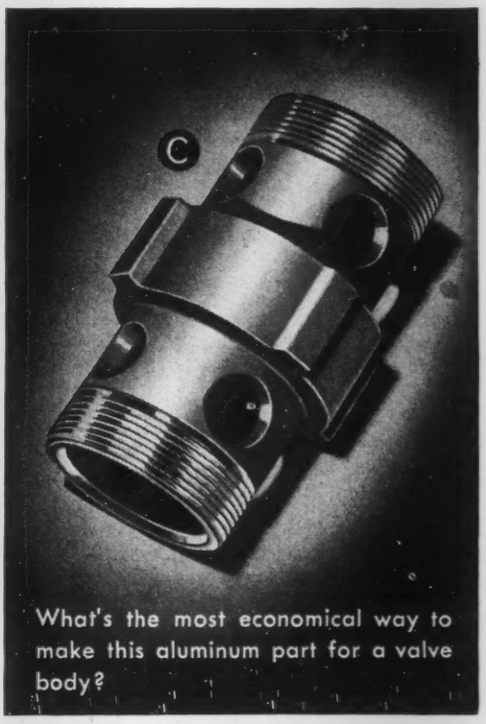
30 East 42nd St., New York, N. Y. UCC Offices in Other Principal Cities

In Canada: Dominion Oxygen Company, Limited, Toronto

# Scovill

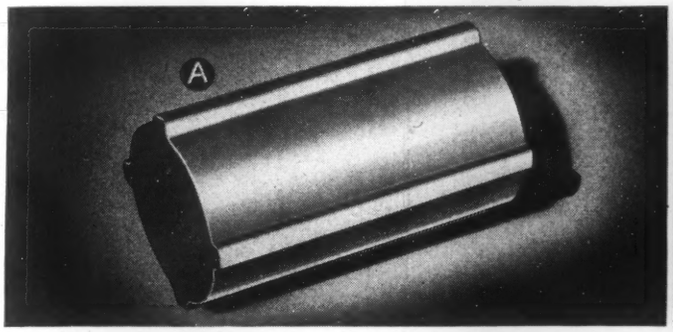
NON-FERROUS

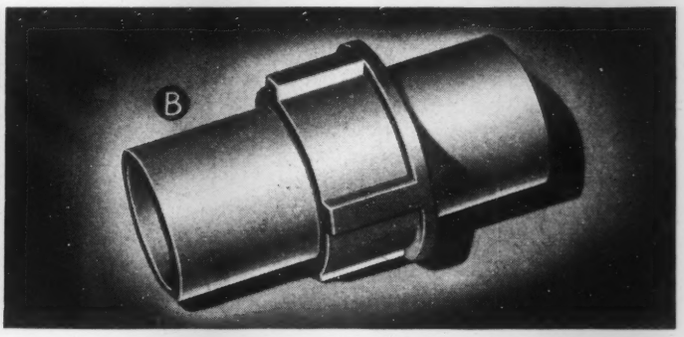
# FORGINGS




What's the most economical way to make this aluminum part for a valve body?

*When SCOVILL becomes your METAL-PARTner ... questions like this are easy to answer:*




Originally made from this special shaped rod — 460 pounds per 1,000 pieces — the part required extensive and expensive machining operations. Compare Parts A and C.

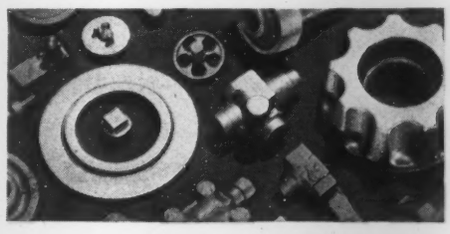
When the part was made as a Scovill Forging, only 220 lbs. of aluminum were needed per 1,000 pieces, and as you can see by comparing Parts B and A, plenty of machining time was eliminated.

*RESULT: Scovill Forgings give the customer considerable savings.*

SCOVILL *Masters of Metal*

**LOOK TO SCOVILL!**

You, as do many of our satisfied customers, may find that your brass, aluminum or other non-ferrous parts can benefit greatly from a change in design or manufacturing method. Out of our backlog of non-ferrous forging experience and ability may come the *extra* that will give you the edge on competition. Let's explore how you may profit from making Scovill *your* METAL-PART*ner*. To start things moving, fill in the coupon and mail it today. Scovill Manufacturing Company, Waterbury 91, Conn. *Export Department:* 405 Lexington Avenue, New York 17, N. Y.



Please send me information about your metal-working facilities. I am interested in non-ferrous forgings for the applications checked:

- ☐ Aircraft
- ☐ Automobiles
- ☐ Band Instruments
- ☐ Blow Torches
- ☐ Cameras
- ☐ Communication Equipment
- ☐ Cylinder Valves
- ☐ Fire Extinguishers
- ☐ Household Appliances
- ☐ Industrial Instruments
- ☐ Plumbing Goods
- ☐ Pumps
- ☐ Valves
- ☐ Welding Equipment

Other applications.....

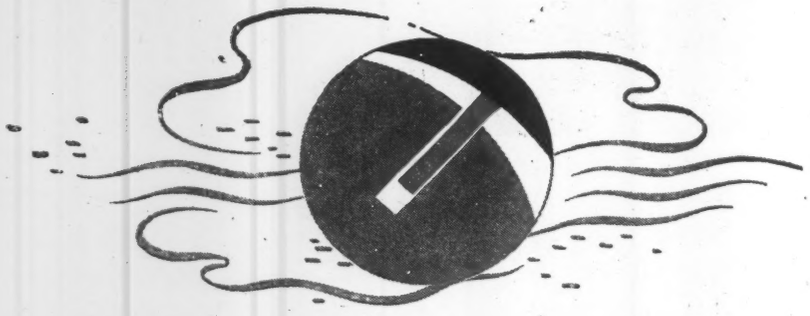
.....

**SCOVILL MANUFACTURING COMPANY**
Forgings Division
19 Mill Street
Waterbury 91, Connecticut

Name .....

Company .....

Address .....



# WHAT— NO "FEATURES"?

*. . in Gast Vacuum Pumps (to 28 in.), Compressors (to 30 lb.), and Air Motors (to 1 h.p.)*

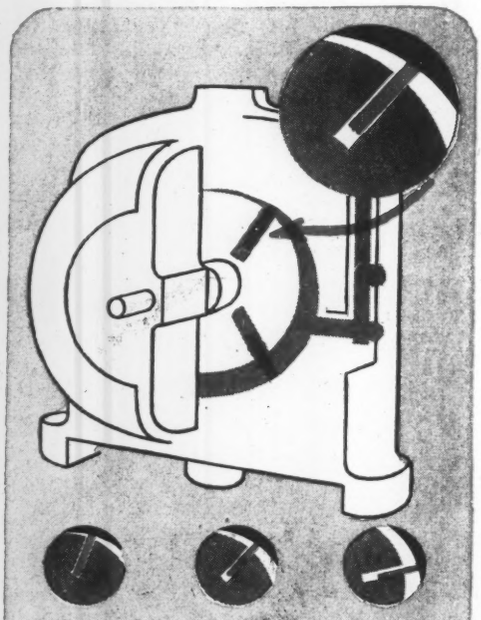
The Gast is so remarkably free of "features" and complexities that users say truly, "It practically works without works."

Could anything be less prone to trouble, or more likely to work, than. A slotted rotor, with one-piece vanes which slide outward against the cylinder walls, and seat themselves, and take up their own inconsiderable wear, because centrifugal force won't let them do anything else?

That's all there is to a Gast. That's why Gasts work so dependably, why they deliver MORE per pound of weight and MORE per horsepower, and why they can be so well built, yet so reasonably priced.

The logic of Gast simplicity appeals strongly to men who manufacture machines. They see that simplicity in terms of sales, and in terms of carefree operation in users' hands. More and more of them are sending for the Gast catalog, and arranging for a Gast Engineering Test. Very possibly it will pay you to do the same.

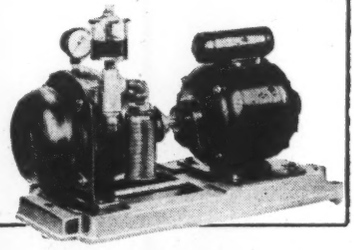
GAST MFG. CORP.
Dept. B, 107 Hinkley Street
Benton Harbor, Michigan



Vanes: Self-seating . . self-adjusting . . springless. Centrifugal force holds them against cylinder wall. They "work without works"... Continuous, non-pulsating flow. . . More air per pound of weight, more air per horsepower. . . Forced-air cooling: long life, oil economy, no hot-oil odor . . . Automatic shaft seal: no packing, no leaking, no adjusting.

## ENGINEERING TEST OFFER . . So You Can SEE IF YOU'RE MISSING SOMETHING!

Simply write our Engineering Department and explain the operation you think air might handle, or describe the job air is already doing for you. Our Engineering Department will study your problem, select or design a Gast unit to do the specified work at less cost or at greater efficiency or both. Then, without cost or obligation, the recommended unit will be shipped to you for your performance tests.

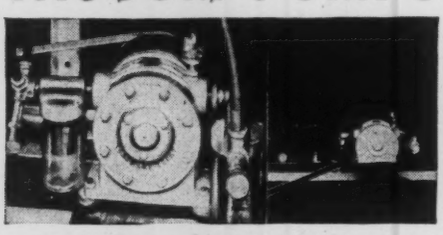


## GET THIS IDEA-CATALOG

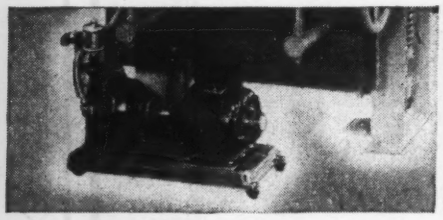
*Is not only tells how Gasts are built and all about them, but suggests uses that may not have occurred to you. Write for it; no charge or obligation!*

# GAST ROTARY

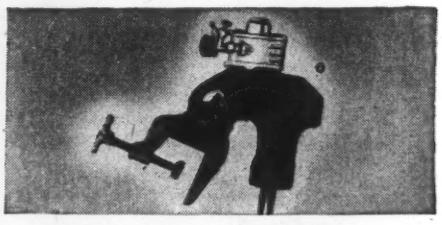
# VACUUM PUMPS · AIR COMPRESSORS · AIR MOTORS



Gast Vacuum Pumps as Standard equipment on a Camera



A Gast Compressor in Combined Vacuum and Pressure Duty on a Printing Press Feeder



A Gast Air Motor as a Portable Mixer

# IMPORTANT IN MODERN DESIGN

SELF-ALIGNING!

PERMANENTLY SEALED!

QUIET!

DEPENDABLE!

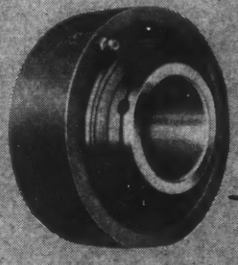
SMOOTH-RUNNING!

Pillow Block

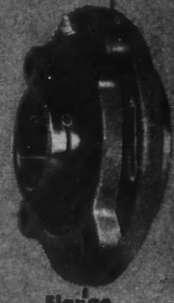
Flange Unit

## SEALMASTER
## BALL BEARING UNITS

Only SealMasters offer this *exclusive combination* of *essential* features that contribute to top bearing performance in new and re-designed machinery and equipment. Specifically, SealMasters provide high load capacity, low maintenance costs, long life . . . and *great overall satisfaction to users.*



Cartridge Unit



Flange Cartridge Unit

**PERMANENTLY SEALED**—SealMaster's patented centrifugal seal effectively excludes dirt and dust . . . and seals in the lubricant.

**PRE-LUBRICATED**—All SealMaster units are properly lubricated at the factory—ready for immediate use.

**SELF-ALIGNING**—The bearing assembly is self-aligning in the housing. Shaft misalignment cannot distort the seal.

**PATENTED LOCKING PIN**—Eliminates housing wear and noise by preventing rotation of outer race. Positions unit for re-lubrication.

*Catalog 845 lists SealMaster Styles, Sizes and Engineering Details*

BEARING DIVISION

# STEPHEN S-A DAMSON MFG. CO.

18 RIDGEWAY AVENUE, AURORA, ILLINOIS ★ LOS ANGELES, CALIF. ★ BELLEVILLE, ONT.

*Factory Representatives and Dealers in All Principal Cities*

Designers and engineers in practically every industry are becoming more and more aware of the remarkable attributes of Superior Nickel Alloy Tubing. Whether it be *Strength, Hardness, Toughness, Corrosion Resistance,* or *Heat Resistance,* the "plus" features of each of these outstanding alloys adds its own particular design and performance advantages.

We are prepared to assist designers and fabricators in the one best selection, of the alloy most logically (and economically) suited to any specific application.

Bulletin 31 is available on request—write for it today.

**SUPERIOR SUPPLIES TUBING in the following analyses**

| | | |
|---|---|---|
| Grade "A" Nickel | "B" Monel | 18% Nickel Silver |
| Electronic Grade Nickel | "K" Monel | 30% Cupro Nickel |
| "D" Nickel (4½ Mn Nickel) | Inconel | "Nichrome V" |

36%, 42%, and 52% Ni Iron

Some are available in both Seamless and WELDRAWN*

*U.S. Trademark

THE BIGGER NAME IN SMALL TUBING **Superior**

see our CATALOG in SWEET'S FILE

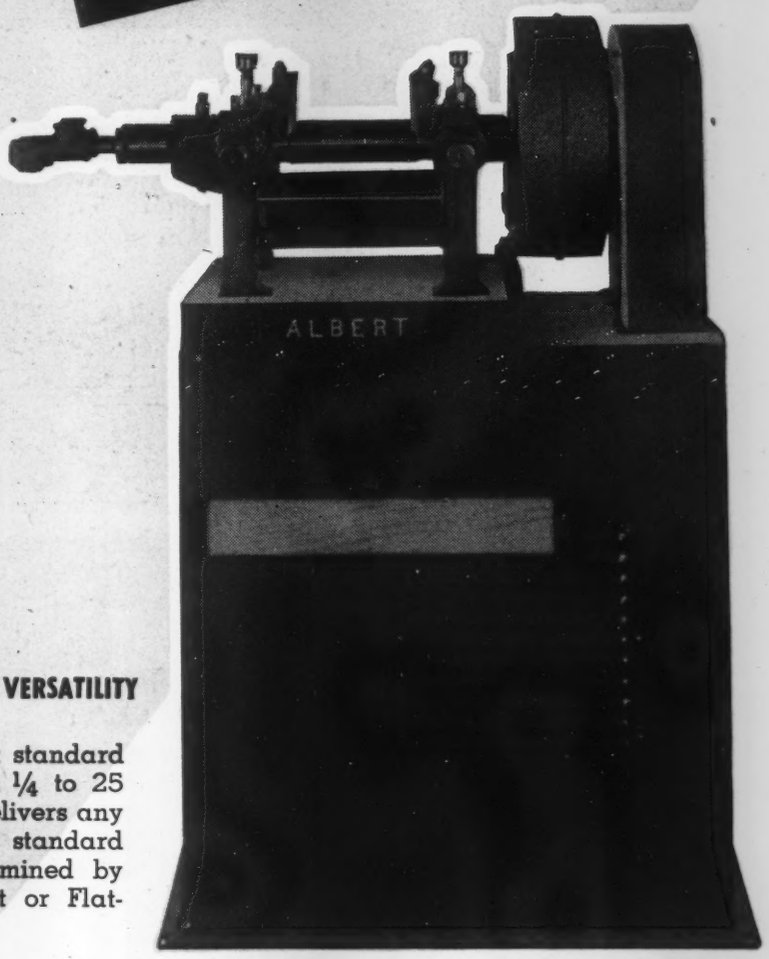
**SUPERIOR TUBE COMPANY**

**Norristown, Pennsylvania**

# HOW YOU CAN SIMPLIFY THE DESIGN OF SLOW-SPEED MACHINES

Take a long look at this machine for milling crude rubber. Here's *real* sales appeal—simple, space-saving design. And you can add these advantages, and more, to your slow-speed machines—by specifying American Reduction Drives. These compact drives mount directly on the shaft of the machine—just as easily as a pulley. There's no need for special foundations or drive supports. And because of their simplicity, only such items as standard motors, sheaves and belts are needed to incorporate American Reduction Drives in your designs.

Decide today—right now—to give your slow-speed machines the simplicity, compactness and cost-reducing advantages of American Reduction Drives. For complete information on their selection, application and installation, write today for the 16-page American Reduction Drives Handbook. Just drop us a line.




The manufacturer who bought this Rubber Mill, equipped with an American Reduction Drive, received even more than clean, compact, space-saving design. He obtained lower operating costs through minimum frictional losses. Moreover, maintenance problems were licked because the primary belt drive absorbed and cushioned shock loads—an exclusive American Reduction Drive advantage.

## SPECIFY AMERICAN REDUCTION DRIVES...FOR VERSATILITY

American Reduction Drives are made in six standard sizes to meet the requirements of drives from 1/4 to 25 horsepower. The reduction unit accurately delivers any speed between 11 and 154 rpm. through its standard ratio of 13 to 1. Output speeds are determined by selecting the proper ratio American V-belt or Flat-belt primary drive.

*The American Pulley Company*

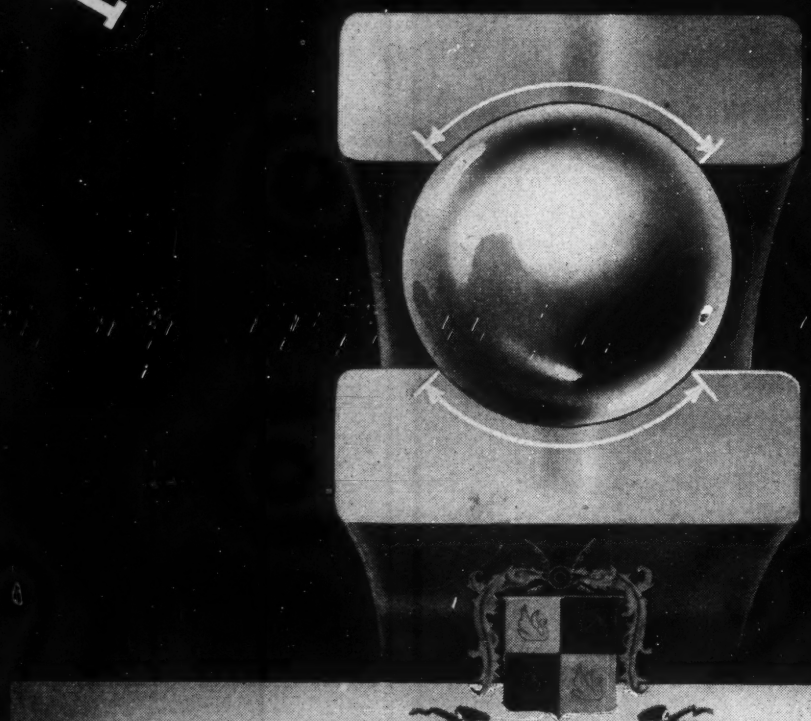
**4236 WISSAHICKON AVE., PHILADELPHIA 29, PA.**

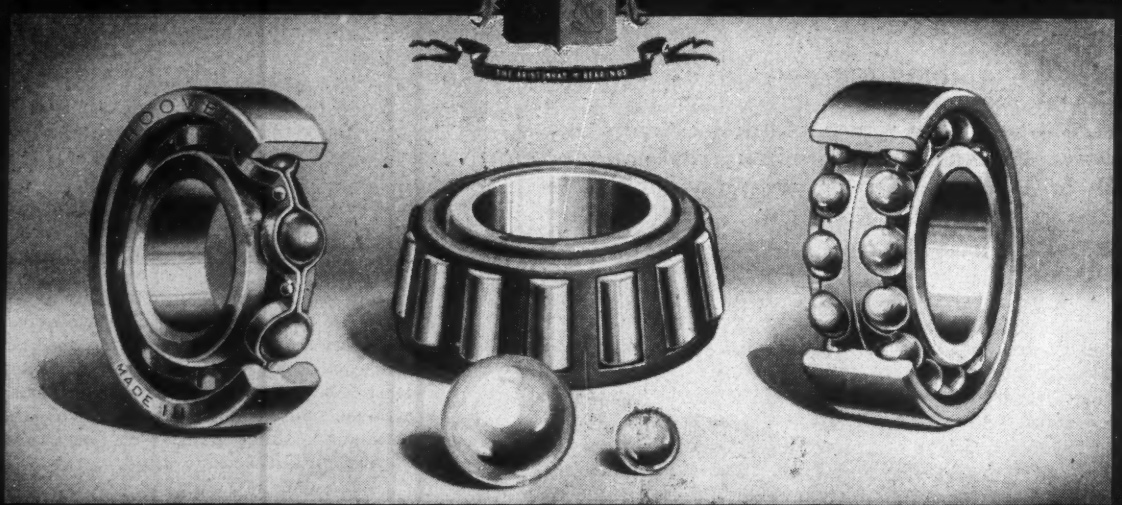
# HONED RACEWAYS

AN EXCLUSIVE HOOVER FEATURE

30%

MORE LOAD—LONGER LIFE



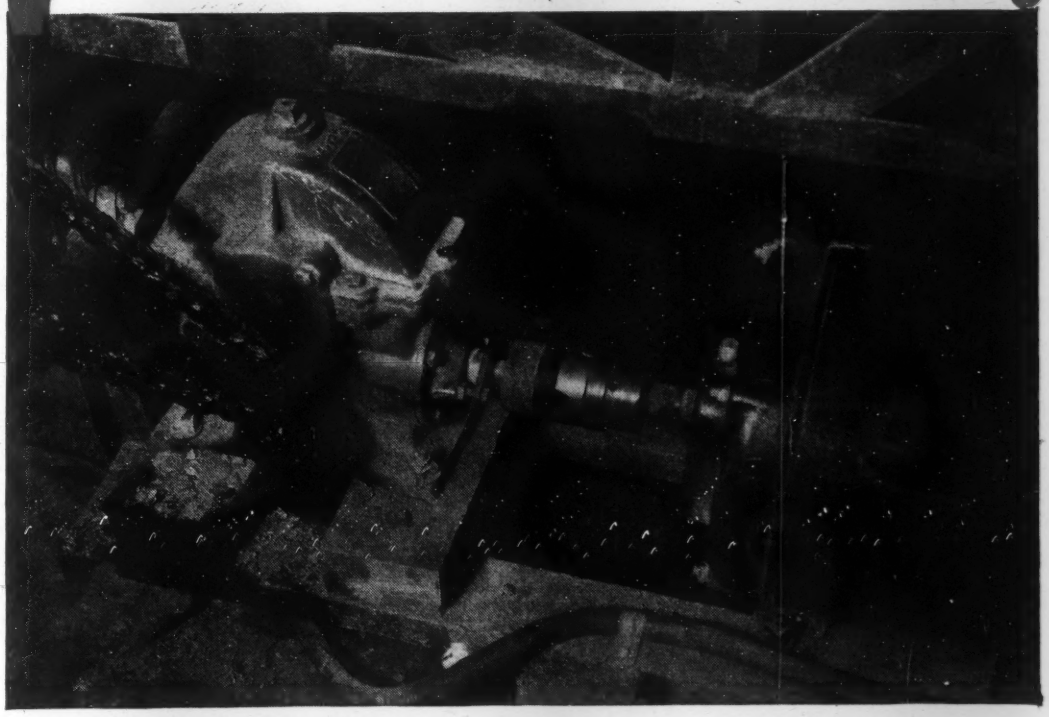



BALLS - BALL BEARINGS - ROLLER BEARINGS

# HOOVER

BALL AND BEARING COMPANY, ANN ARBOR, MICHIGAN

# NOW YOU CAN CUT COUPLING COSTS DO A BETTER COUPLING JOB!



*6 months brickyard operation—still going strong.* Unretouched photo of main drive on a portable conveyor at a brickyard in Bridgewater, Mass. IMW coupling connects motor and speed reducer. Note thick coating of brick dust, flimsy structural frame (subject to weaving)—also marked parallel and angular misalignment corrections. 6 months of steady punishment—still asking for more.

## This new, simpler, self-lubricating gear-tooth flexible coupling is less expensive — longer lasting

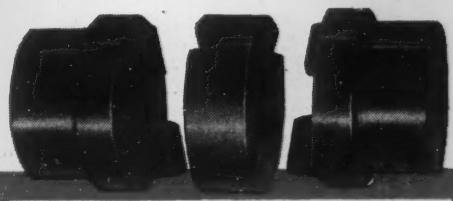
Here is an important *new* development in coupling design— a 3-piece gear-tooth flexible coupling that will save you money—make installation easier—increase coupling efficiency.

Two identical steel end-pieces with involute gear-teeth mate with self-lubricating centerpiece of lubricant-impregnated sintered bronze, containing rack grooves running transversely on opposite sides. Each end-piece has two set screws—one on key and one 120° from key way.

Proved repeatedly in actual plant performance, this revolutionary new IMW gear-tooth coupling* has demonstrated a combination of advantages never before available.

- *Corrects angular and parallel misalignment* simultaneously — self-lubricating.
- *High torque capacity* — suitable for high-speed application up to 1500 inch-pounds torque (in standard sizes).
- *Greater flexibility* — longer life — quieter, more efficient operation — less vibration.
- *No backlash* — all metal — easy to install and inspect.

Broad range of standard sizes up to 1¾ inch shaft diameter. Special sizes to specification. Write, or mail coupon—today—for full information.



**ROCKS to correct angular *misalignment***

Correction up to 2° either side of center

**SLIDES to correct parallel *misalignment***

Liberal correction depending on size of coupling

*Patent Pending.

IMW GEAR-TOOTH COUPLING

CLIP and MAIL THIS COUPON TO

**INDUSTRIAL MACHINE WORKS, INC.**
South Hanover, Mass.

**INDUSTRIAL MACHINE WORKS, INC.**
20 Winter St., South Hanover, Massachusetts

Please send me your catalog giving additional detailed data on IMW Flexible Couplings.

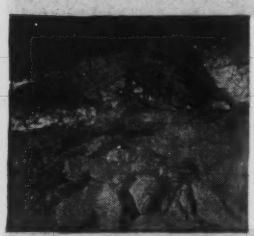
*Name* .....

*Business or Home Address* .....

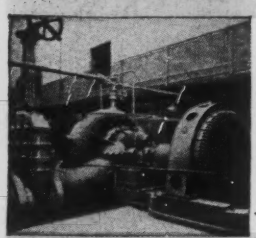
# INDUSTRY BANS RUST AND CORROSION *with* EVERLASTING FASTENINGS

Few industries can escape the destructive effects of rust and corrosion but *all* industries can reduce their costly ravages in maintenance and breakdown.

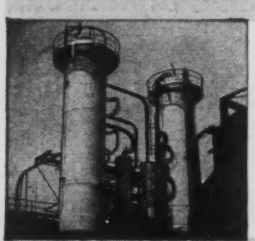
Here are five industrial applications where Harper's EVERLASTING FASTENINGS have licked rust and corrosion.



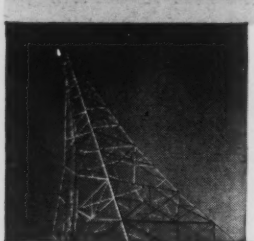
**MONEL STOPS CORROSIVE CHEMICALS** Problems in salt production have been solved by using Monel bolts. In mining, treating and handling of many chemicals, nonferrous alloys are the answer to efficient operation.



**BRASS GUARDS WATER SYSTEMS** In valves and pumps that compose the heart of water works, Brass fastenings help in eliminating the most common cause of replacement—rust.



**STAINLESS STEEL SOLVES OIL PROBLEMS** Acids and gases at high temperatures attack metal but Stainless Steel alloys cut refinery replacements to a minimum, assure years of continued operation.



**UTILITIES CHOOSE SILICON BRONZE** Weather is the bug-a-boo in power lines and other utility applications. Silicon Bronze Bolts reduce season "cracking" and maintenance costs.

**NAVAL BRONZE WINS ON THE SEA** Marine applications demand high strength plus resistance to salt air and water. Naval Bronze fastenings have proved their dependability in marine diesels and ship fittings.

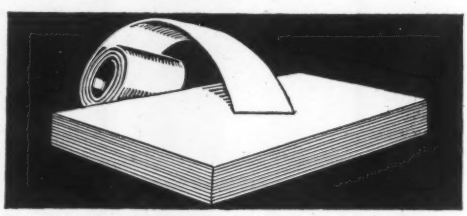
**THE H. M. HARPER COMPANY** 2626 Fletcher Street Chicago 18, Illinois

Branch Offices:
New York City
Philadelphia
Los Angeles
Milwaukee
Cincinnati
Dallas
Representatives in Principal Cities

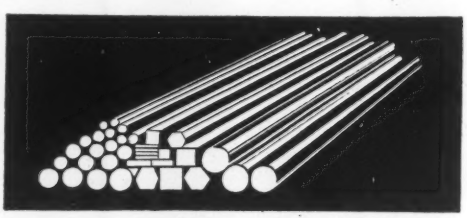
Call upon Harper to solve fastening problems in *your* industry

# ELEPHANT BRAND
## PHOSPHOR BRONZE

WIRE in coils for spring manufacturers; Flat wire in coils or lengths; Tinned binding, for armature work; Straightened (round), in lengths All wire can be supplied bright-annealed.



SHEETS in rolls; Slit sheet metal, tinned both sides—in various gauges and tempers covering a broad range of uses.



RODS up to 6" diameter, in Round, Square and Hex . . . available now for prompt delivery.

Elephant Brand Phosphor Bronze has been used by thousands of manufacturing firms in all branches of industry for nearly three-quarters of a century—Since 1874 manufacturers of nothing else but Phosphor Bronze.

**THE PHOSPHOR BRONZE SMELTING COMPANY**
2200 Washington Ave., Philadelphia 46, Pa.

Please send me a copy of your Technical Data Book.

NAME ..... TITLE.....

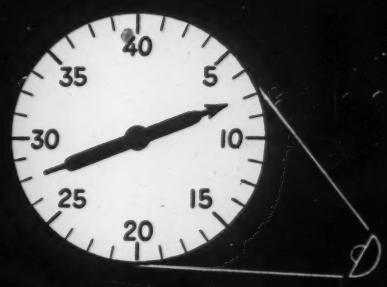
FIRM .....

ADDRESS .....

**Self-Luminous** — Radioactive markings and pointers shine brightly in darkness, are clearly readable without use of any outside light source.

**Fluorescent** — Fluorescent markings and pointers shine brightly under ultraviolet radiation. Brightness is controllable.

**Phosphorescent** — Phosphorescent markings and pointers have a useful afterglow following activation by ultraviolet or visible light.




**Nonluminescent** — The U. S. Radium Corporation has complete facilities and skilled personnel for the production of high-precision dials.

# *Which type of dial best meets your need?*

Whether your primary interest is accuracy, handsome appearance, low cost, or clear readability in daylight, artificial light, or darkness — or a combination of any or all of these characteristics — the United States Radium Corporation is prepared to meet your dial requirements exactly.

The many thousands of U. S. Radium dials in service in aircraft, industrial, and scientific instruments testify the quality and satisfaction *you* can expect when you specify "U. S. Radium dials and pointers".

Tell us what kind of dial you're interested in, and we'll send you a sample from our current production. Write *Dept. G8, United States Radium Corp., 535 Pearl Street, New York 7, N. Y.*

**OTHER PRODUCTS OF U. S. RADIUM**

- **RADIOACTIVE FOILS** *(alpha-ray ionization sources)*
- **IONOTRON STATIC ELIMINATORS** • **RADIUM LOCATORS:** *pendants, lenses, buttons, screws, markers*
- **LUMINOUS RETICLES** *and other specialties*
- **POWDERS:** *cathode-ray tube and television tube*
- **SILHOUETTE ILLUMINATION** *of clocks, watches and instruments*

US RADIUM

**UNITED STATES RADIUM CORPORATION**

4 CYCLE
BRIGGS & STRATTON
GASOLINE ENGINES

# Your Assurance of All that is Best in Gasoline Engine Performance

Through more than 27 years, Briggs & Stratton 4-cycle *air-cooled* gasoline engines have demonstrated they have the stamina to give *maximum performance* under severest conditions of long, hard use. By this record of *dependable* operation, they *earned* worldwide recognition as the "right power" for all types of appliances, farm machinery and industrial equipment. Only by specifying Briggs & Stratton engines can users, dealers and manufacturers benefit by the long experience, technical knowledge, and manufacturing facilities of an organization which has built over 2¾ million Single Cylinder *air-cooled* engines.

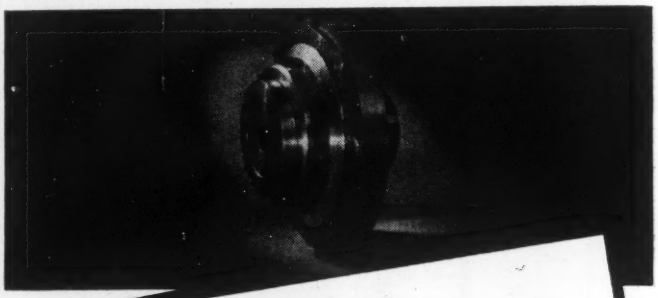
**BRIGGS & STRATTON CORP.**
**Milwaukee 1, Wisconsin, U. S. A.**

*Air-Cooled Power*

*"Preferred Power"*
FOR INDUSTRIAL, CONSTRUCTION RAILROAD AND FARM EQUIPMENT

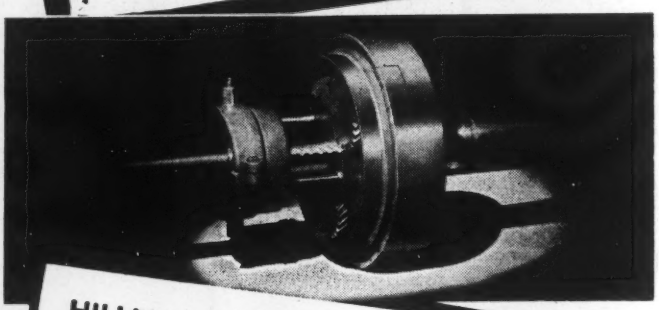
# *Clutches by* HILLIARD

## HILLIARD CLUTCHES AND COUPLINGS ARE EXCELLENT FOR ALL CLASSES OF MACHINERY



### HILLIARD SLIP CLUTCH

A reliable series of spring-loaded slip clutches and couplings made in a variety of types. Outstanding for—reeling and winding operations—tension drag brakes—limiting torque—preventing overloads and shocks—starting heavy loads—and many other uses.



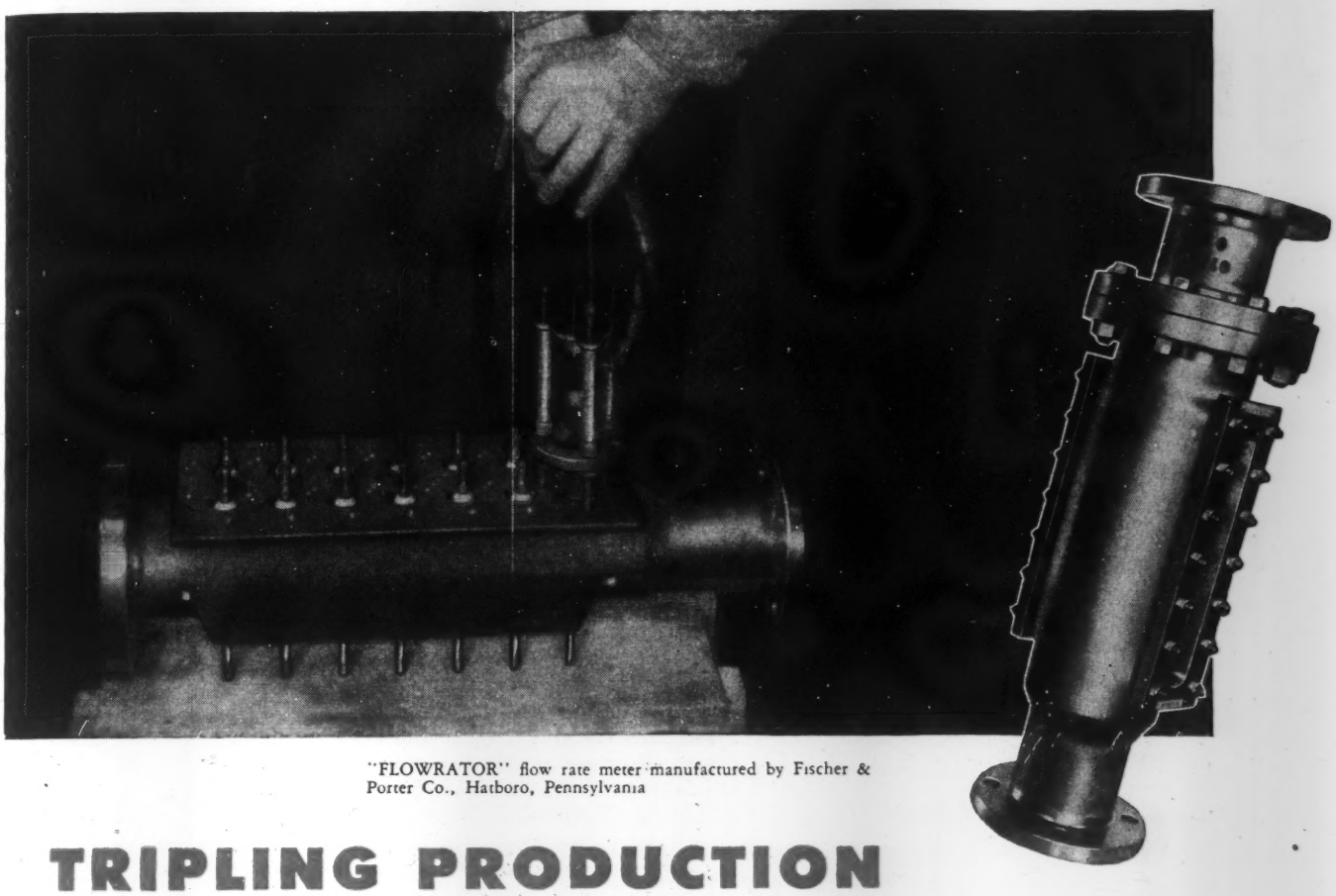
### HILLIARD FRICTION CLUTCH

Hilliard Friction Clutches and Couplings are especially suitable for drives requiring smooth clutching and infrequent clutch adjustment. Their rack and gear mechanism permits very slow engagement of friction surfaces, resulting in extremely smooth load acceleration, always under control.

★ **WRITE TO-DAY!**

**For the new series of 6 illustrated Bulletins furnished FREE upon request. Featuring our complete line of Industrial Clutches and Couplings — Over-Running—Single Revolution—Friction—Centrifugal—Overload Release---Slip.**

**THE HILLIARD *Corporation***
103 W. Fourth St. Elmira N. Y.
MANUFACTURERS OF INDUSTRIAL CLUTCHES



"FLOWRATOR" flow rate meter manufactured by Fischer & Porter Co., Hatboro, Pennsylvania

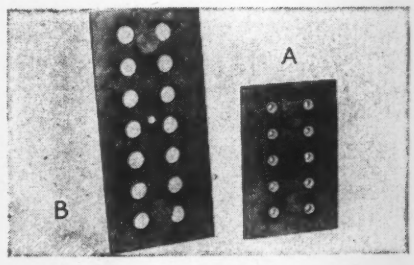
# TRIPLING PRODUCTION at the pull of a trigger . . .

It takes 28 studs to secure the two gauge glass hold-down flanges on the Fischer & Porter "Flowrator" pictured above. Formerly, stud installation required drilling 28 holes in the stainless steel casting, tapping each of the 28 holes, and screwing in 28 studs . . . 84-slow, costly operations per unit.

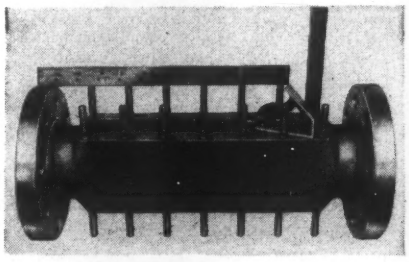
NELSON Automatic Stud Welding trebled production by reducing stud installation to one trigger-quick operation per stud. The operator merely loads the NELSON flux-filled stud with its protective ferrule in the gun chuck, locates the gun legs in the simple template shown, and pulls the trigger. A standard d.c. welding generator furnishes the current, and the NELSON Timer Control unit automatically times the weld cycle. On the job illustrated, the operator averages 150 stud welds per hour.

A three-fold increase in production was but one of the advantages Fischer & Porter gained by adopting NELSON stud welding. Because no holes are drilled in the casting, possibility of leaks around stud holes are eliminated. Slight porosities in the casting encountered in drilling stud holes required expensive filling, or discard of the casting. As no holes are now drilled, porosities are no longer a problem and casting rejects are at a minimum.

If your product uses studs, there's a very good chance that you, too, can save hours and dollars with NELSON Automatic Stud Welding. Full details are yours for the asking . . . write or wire us *now*.




SIMPLE TEMPLATES ASSURE ACCURACY, HIGH PRODUCTION SPEED—Fischer and Porter use two types of inexpensive templates made from ¼" plate to speed accurate stud location. The "tight hole" type (A) locates by means of pilot holes drilled to take the NELSON ferrules with a snug fit. Ferrules are dropped in place and studs welded through ferrules. The "leg positioning" type (B) locates by means of 3 countersunk spots to match the 3 gun leg tips.



Extreme accuracy of location, stud height and alignment are demonstrated in the photo above.

**NELSON SALES CORPORATION**
**2703 TOLEDO AVE.**
**LORAIN, OHIO**

Representing

| | |
|---|---|
| Nelson Stud Welding Corporation Lorain, Ohio | Nelson Specialty Welding Equipment Corporation San Leandro, California |

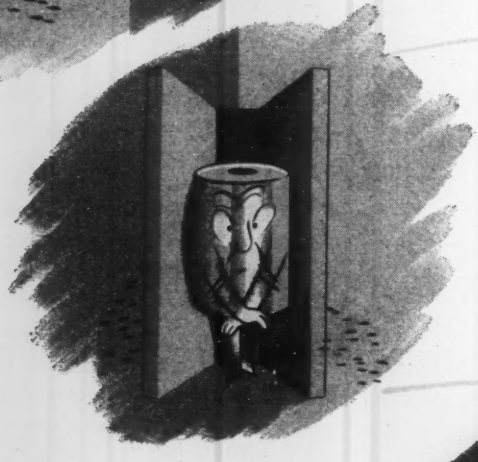
NELSON

TRADEMARK

# gramix bearings and structural parts cost less . . . last longer

**Lubricates Itself.** Gramix parts are made by die-pressing powdered copper, iron, and other metals to desired shape and size. Their porosity permits impregnation with any one of a wide variety of lubricants to meet practically every requirement. Self-lubricating Gramix parts lessen maintenance costs, greatly minimize chances of costly bearing failure.

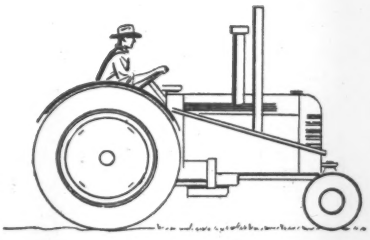
**Fine Surface Finish.** The extremely high pressures under which the powdered metals are compacted leaves Gramix parts with smooth, unblemished surfaces perfect for sliding or bearing. This eliminates expensive machining and scraping operations, assures you of mechanical parts ready-made for installation.



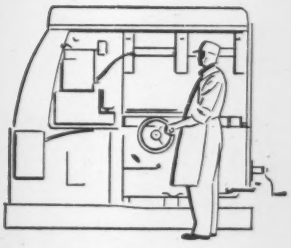
**Close Tolerances.** Gramix parts can be made to any reasonable tolerance on all dimensions. For example, ID's can be held to .0003". No machining is necessary. In the manufacture of small parts for washing machines, electric fans, sweepers, and other mechanisms, Gramix simplifies production and effects economies which result in greater profits.

**Made In Most Shapes and Sizes.** Gramix parts can be made in an almost unlimited number of shapes and sizes. They are now delivering dependable performance in such products as refrigerators, pumps, diesel engines, farm implements. Send us a sketch or blueprint of your products, and our engineers will help you determine if Gramix will be of advantage in your manufacturing.

THE UNITED STATES GRAPHITE CO. • SAGINAW, MICHIGAN



**From Farm Machinery**



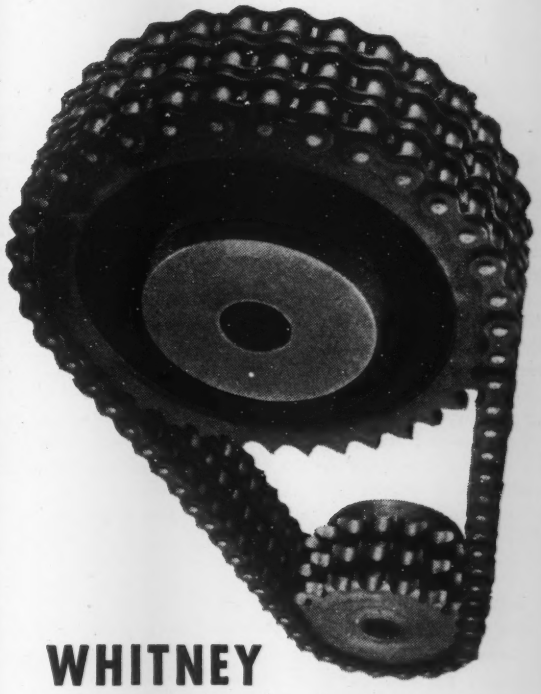
**To Machine Tools...**

# Chain Drive IS BETTER

- *ADAPTABLE TO ALL DESIGN PROBLEMS*
- *POSITIVE GRIP ASSURES EFFICIENT POWER TRANSMISSION*
- *LONG OPERATING LIFE WITH MINIMUM MAINTENANCE*

Whether it's stationary or portable equipment . . . textile or agricultural machinery . . . chain power drive gives highest transmission efficiency. The positive grip eliminates power loss due to slippage and frictional contacts. Because chain drive transmits constant motor speed, it helps maintain product uniformity, cuts down rejections. Its flexibility and adaptability simplify design problems . . . provide a wide range of selection to every application. Chain drive is easy to install, easy to remove without disconnecting shafts . . . has high shock load capacity . . . does not require frequent adjustments to maintain tension . . . gives long-lived performance with little maintenance.

Investigate chain drive for your designs. Whitney Engineers will gladly help you with your problems. Write:



## WHITNEY ROLLER CHAINS

These chains deliver constant, full power smoothly and efficiently. They stand up under the severest operating conditions. All parts are made of alloy steel, hardened to give maximum service with minimum wear. Whitney Roller Chains are available in many types in pitches from $\frac{3}{8}''$ to $2\frac{1}{2}''$. Write for complete specifications.

**The Whitney Chain & Mfg. Company, Hartford 2, Connecticut**

**YOUR WIFE'S HAT...**

**AND AN**

***Armature Shaft's Protection***

Photograph Courtesy Merrimac Hat Co.

*have much in common!*

*Felt Roller Bearing Wick, showing an ingenious method of reservoir filling. Metal feed tube insert permits rapid oil replacement. While the oil is moving to the friction point, it is being filtered . . . freed from impurities.*

Yes indeed, the smart Felt "creation" from the milliner's on the Avenue . . . and the humble Felt wick or pad that solves difficult machine lubrication problems are both *felted* from lamb's wool.

Nothing but Felt will hold oil ready to bleed immediately at dangerous friction points. This "watch dog" alertness of Felt results from its capillarity — makes it the preferred agent for lubricating large and small armature shafts, journal bearings, spindles and remote machine parts. Felt pads absorb, store and distribute oil, water, ink and other process fluids in automatic printing equipment, numbering and postage machines.

There are many other uses of Felt in industry — as shock, vibration and sound-absorber, thermal insulator, polisher, spacer. To obtain the benefits of technological advances in Felt, consult an American Felt Company sales engineer or write on your letterhead for appropriate Data Sheets and samples of Felt.

**AMERICAN FELT COMPANY DATA SHEETS**

*Write for those you need to complete your Felt reference file.*

- No. 1—Felt Density and Hardness
- No. 2—Adhesives for Felt Application
- No. 3—"K" Felt—Sound Absorption and Thermal Insulation
- No. 4—Special Felt Treatments
- No. 5—S.A.E. Specifications and U. S. Navy 27F7
- No. 6—Felt and Lubrication
- No. 7—A.S.T.M. Methods of Test for Wool Felt, D461
- No. 8—U. S. Army Specification No. 8-15G
- No. 9—Sheet Felts, standard Grades and Specifications
- No. 10—Vibration Isolation With Felt
- No. 11—Felt Seals, Their Design and Application
- No. 12—Flame-proofed Felt
- No. 13—Felt in Compression
- No. 14—Vistex—Packings, Gaskets, Seals

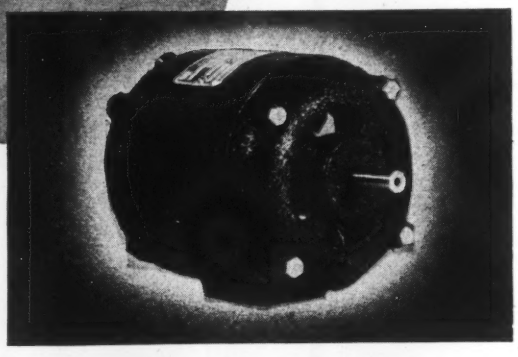
**American Felt Company**

TRADE MARK

*General Offices:* GLENVILLE, CONN.

*New York; Boston; Chicago; Detroit; Philadelphia; Cleveland; St. Louis Atlanta; Dallas; Los Angeles; Seattle; San Francisco; Portland*

# ELINCO



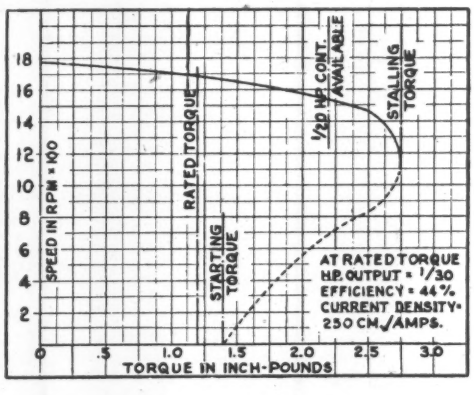
# NEW TYPE "ALP"

## CAPACITOR-TYPE MOTORS

Elinco sub-fractional horsepower motors are now available in the new "ALP" Frame, 3⅜" x 4$\frac{5}{16}$", as capacitor start and run, two and four-hole AC motors, internal fan cooled. As induction motor to 1/30 h.p. at 1700 r.p.m.; as synchronous motor to 1/60 h.p. at 1800 r.p.m. Substantially higher ratings are available at speeds of 3400 and 3600 r.p.m. respectively. Also, higher ratings for intermittent duty.

**TYPICAL PERFORMANCE CURVE**

For Type ALP-191, 110 volt 60 cycle single-phase Capacitor start and run; Motor Capacitor Value 4.25 Mfd. Curve #235.




**HIGH-QUALITY PRECISION INSTRUMENT TYPE MOTORS AND GENERATORS EXCLUSIVELY**

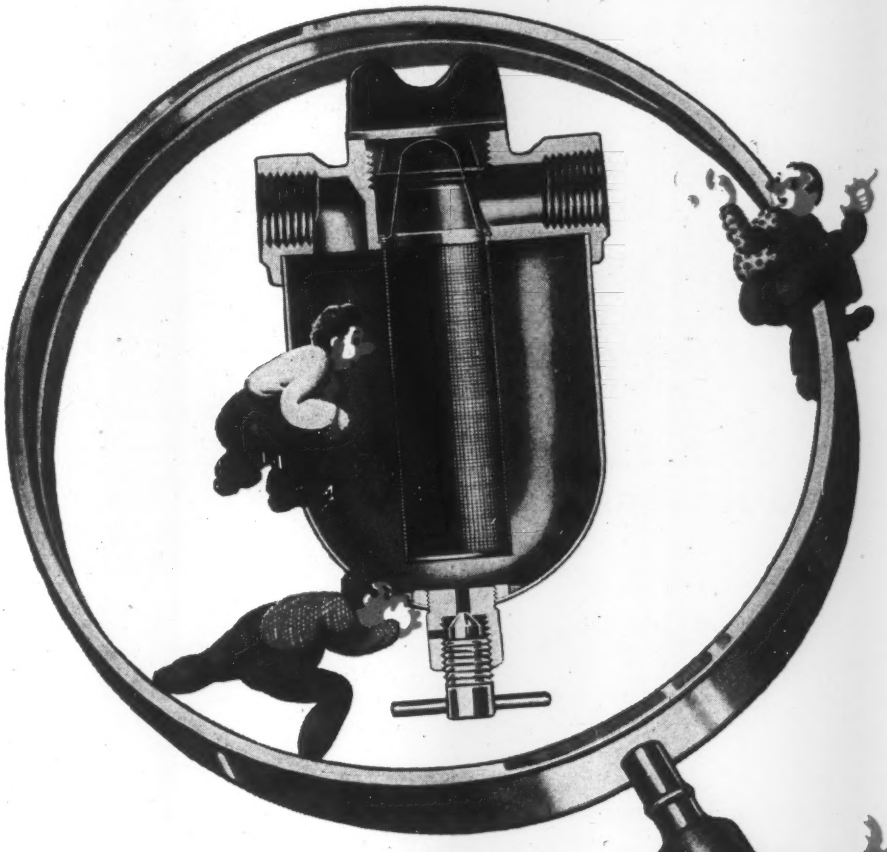
All motors and generators ball-bearing type; can be mounted in any position. Housings and end bells of cast aluminum; dynamically-balanced rotors; special finishes can be provided to meet varying conditions of climate and usage. Units ordered can be either standard or special models; different shaft diameters, lengths, or changes in dimensions, as well as alterations in electrical characteristics, can be specified. Design and engineering service available. The production of fine precision units to blueprints or specifications is our specialty.

*Write for Temporary Bulletin 46-A*

**ELECTRIC INDICATOR CO.**

STAMFORD U.S.A. CONN.

# WORTH LOOKING INTO



Norgren

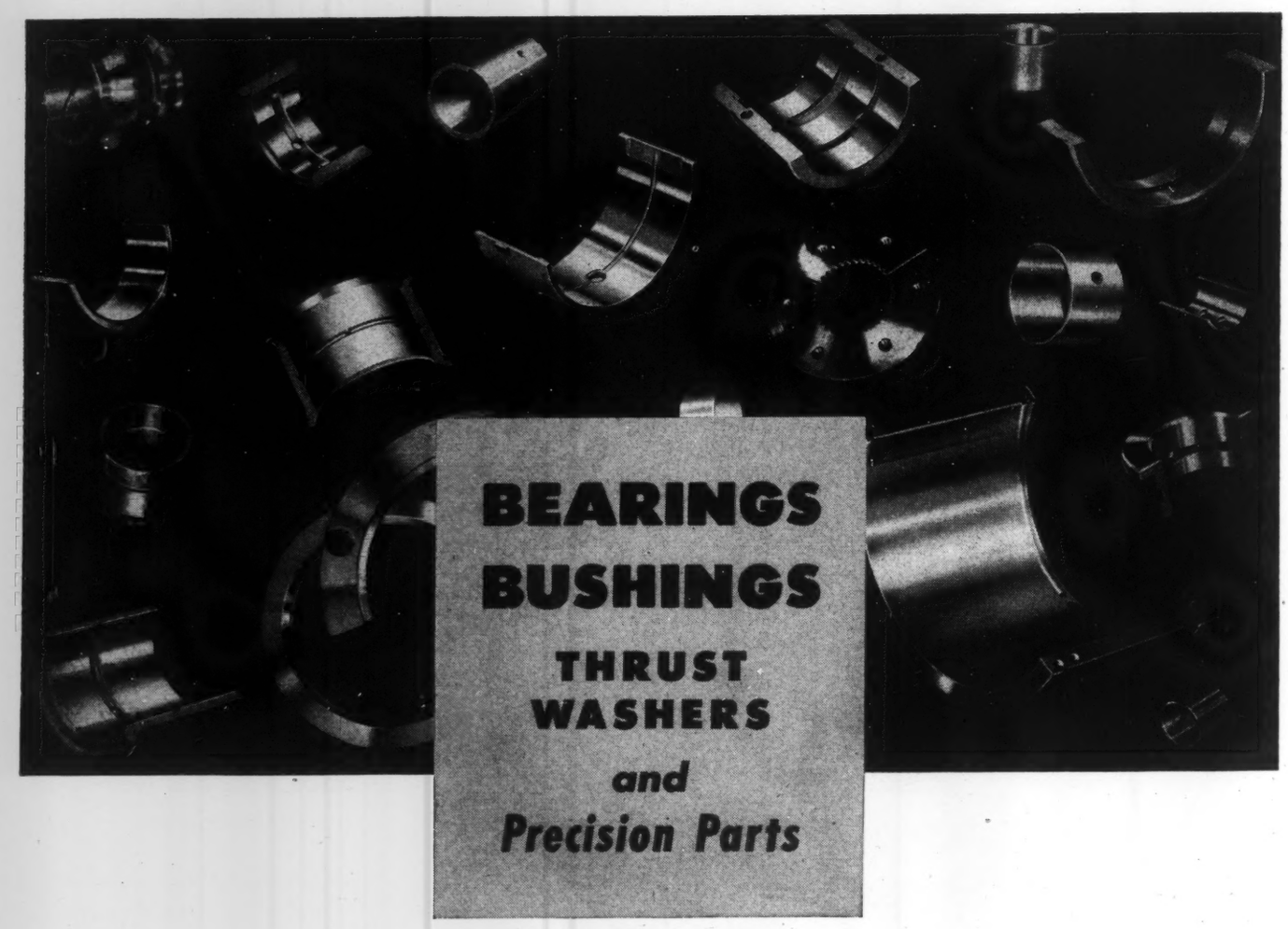
## Norgren FILTERS

**stop destructive dirt and pipe scale, and oil emulsion and corrosive moisture from reaching air driven tools and cylinders. Deliver clean, dry air for continuous, economical, top performance with less wear and no maintenance.**

A precision-built steel and brass unit. Double Monel wire screen. Easy to clean—No moving parts to wear out—No interruption of service. Dirt falls to bottom of bowl; open waste cock—blow it out.

Norgren Filters improve performance, cut repairs and costly replacements. Look into this, today. Write C. A. Norgren Co., 220 Santa Fe Drive, Denver 9, Colorado.

**Norgren Filters are used alone or as an indispensable third of the *Lubro-Control Unit,* a compact assembly of Filter, Regulator and Lubricator which *cleans, controls and lubricates* the air that drives the tool for more efficient and profitable operation of all types of pneumatic equipment.**




In six modern plants we produce steel back bearings lined with tin-base babbitt, cadmium-silver alloy, high-lead babbitt, copper-lead alloy and bronze; bronze-back babbitt-lined bearings; cast iron back babbitt-lined bearings; die-cast bearings and bushings, and bronze bushings. Each plant manufactures within a definite range of sizes and alloy combinations. This production flexibility permits us to meet quality, quantity and cost requirements.

We specialize in the production of unusual bearing sizes (up to 27½" O.D.), also in thrust washers, precision bronze parts and aluminum alloy bearings. Capacity for these, with immediate delivery, is available. Complete research and engineering facilities are at your service. Your inquiry is invited.

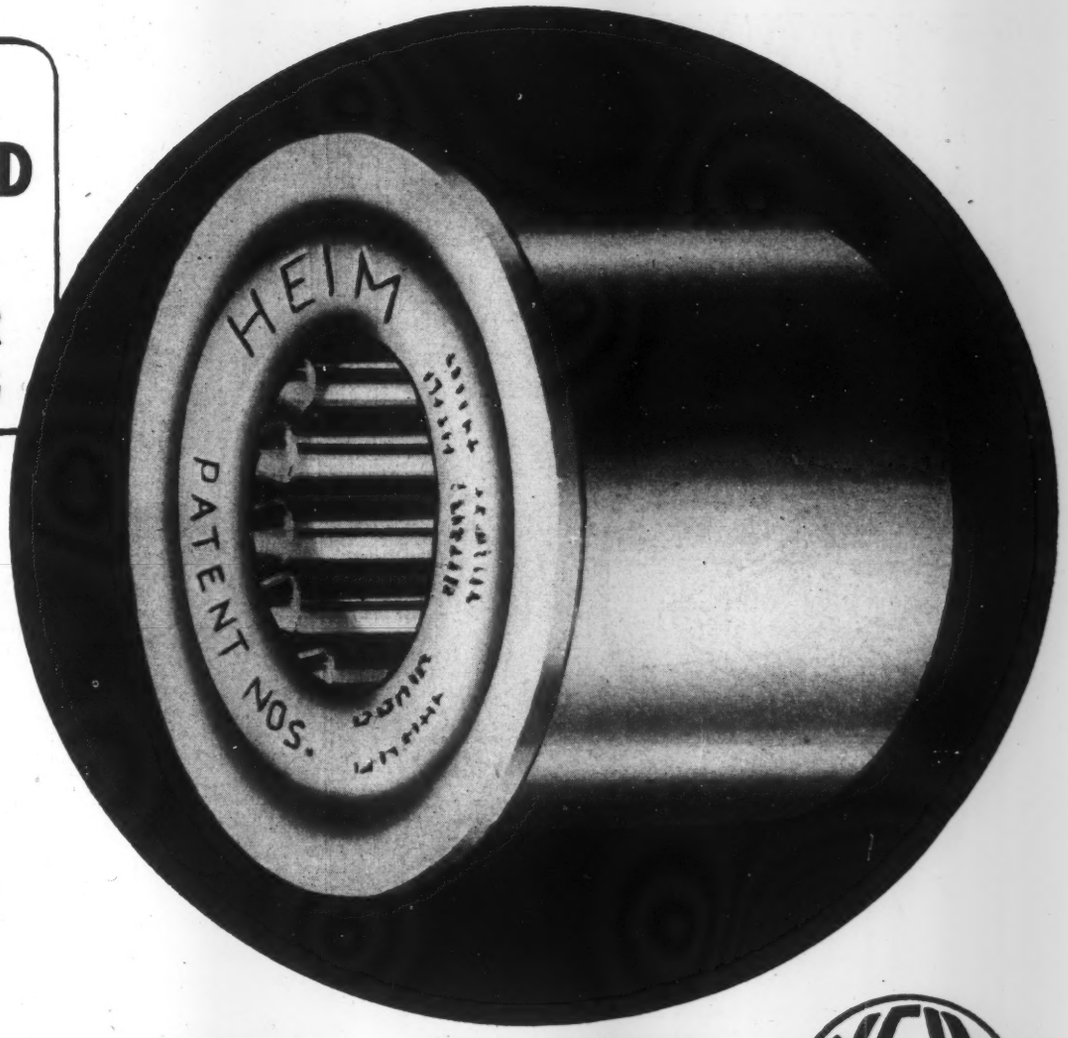
**FEDERAL-MOGUL CORPORATION • 11045 Shoemaker, Detroit 13, Michigan**

***Power goes to work smoothly through***

# FEDERAL-MOGUL

*Silent* FEDERAL Mogul **SLEEVE BEARINGS**

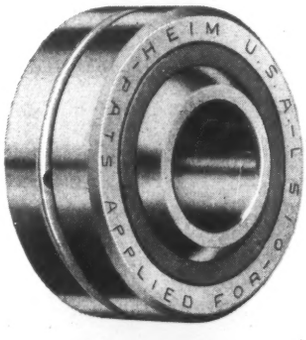
# HEIM FLANGED TYPE ROLLER BEARING




## A SELF CONTAINED, LOW COST, ROLLER BEARING

HEIM

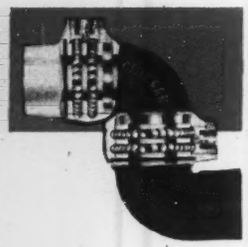
**The Heim Flanged Roller Bearing consists of an outer casing and an inner roller race formed from sheet metal, and a full complement of rollers. Accurate forming dies result in a uniformity of size and contour. Flanges retain the lubrication and exclude dirt and foreign matter. Ease of mounting and low cost make these bearings admirably suited to such equipment as factory trucks, wheelbarrows, casters, hoists, dollies, and a host of others where a dependable, low cost, self contained, anti-friction bearing is required. Please write for further details and a complete catalog of Heim bearings.**




***Other HEIM products include UNIBAL Spherical Bearings, Spherical Bearing Rod Ends, Die Polishing Machines***

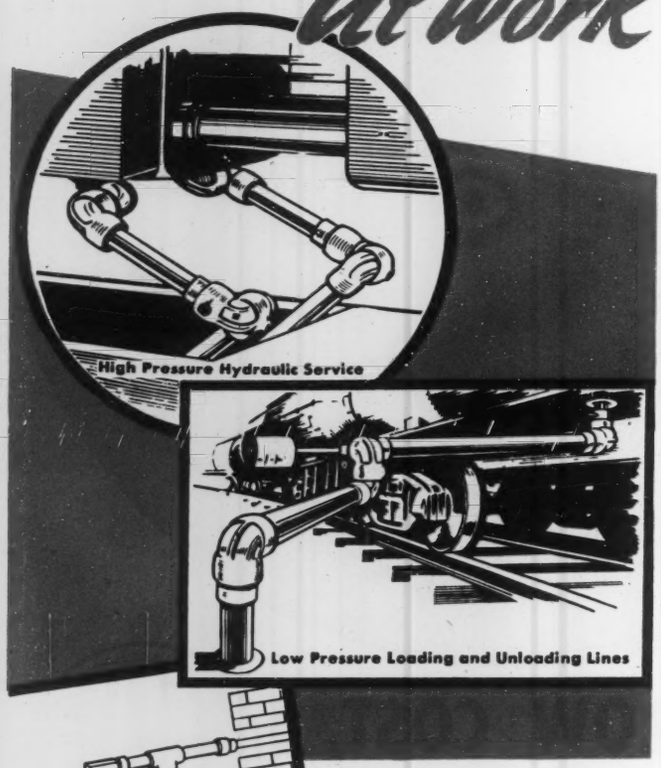
**THE HEIM COMPANY**
**FAIRFIELD CONNECTICUT**

# CHIKSAN



## BALL BEARING SWIVEL JOINTS

*At work*




Look around you and you will see CHIKSAN *Ball-Bearing* Swivel Joints at work in many different applications...from low pressure loading and unloading lines to high pressure hydraulic equipment and under high temperatures on boilers and open hearth furnaces. CHIKSAN Swivel Joints are made in over 500 different Types, Styles and Sizes... for pressures from 300 psi to 12,000 psi and temperatures to 500° F....for full 360° rotation in 1, 2 and 3 planes...with threaded or flanged ends or bored for welding.

Write for CHIKSAN CATALOG No. 45.

*REPRESENTATIVES IN PRINCIPAL CITIES*

EXPORT REPRESENTATIVE: Chiksan Export Co., Brea, California
Branches: New York 7, Houston 2

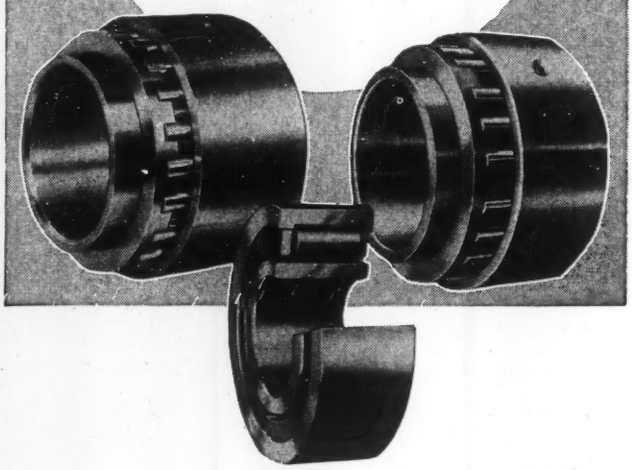
CHIKSAN BALL BEARING SWIVEL JOINTS FOR ALL PURPOSES

CHIKSAN COMPANY
BREA, CALIFORNIA



*EVERYONE KNOWS THE BURDENS THEY BEAR*

AMERICAN
HEAVY-DUTY
SUPER HEAVY-DUTY
RADIAL
ROLLER BEARINGS



AMERICAN ROLLER BEARINGS of all types are built specifically to "bear up" under the terrific stresses and strains encountered in the world's most powerful industrial and oil country machinery. Their superior strength, long life and proven ability to render smooth, quiet, trouble-free service has made them favorites with heavy equipment manufacturers for more than 25 years.

Why don't *you* specify AMERICANS for your next *heavy-duty* application? Our engineers will gladly cooperate in solving all your roller bearing problems.

**AMERICAN ROLLER BEARING COMPANY**
**Pittsburgh, Pennsylvania**

Pacific Coast Office:
1718 S. Flower St., Los Angeles, California

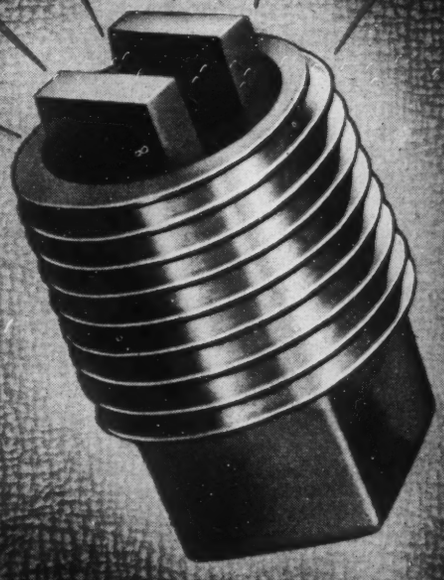
AMERICAN ROLLER BEARINGS HEAVY DUTY

**AMERICAN**
*Heavy-Duty* ROLLER BEARINGS

# A MAGNET that Prevents Bearing Failures

## Pulls Iron and Steel Particles Out of Oil

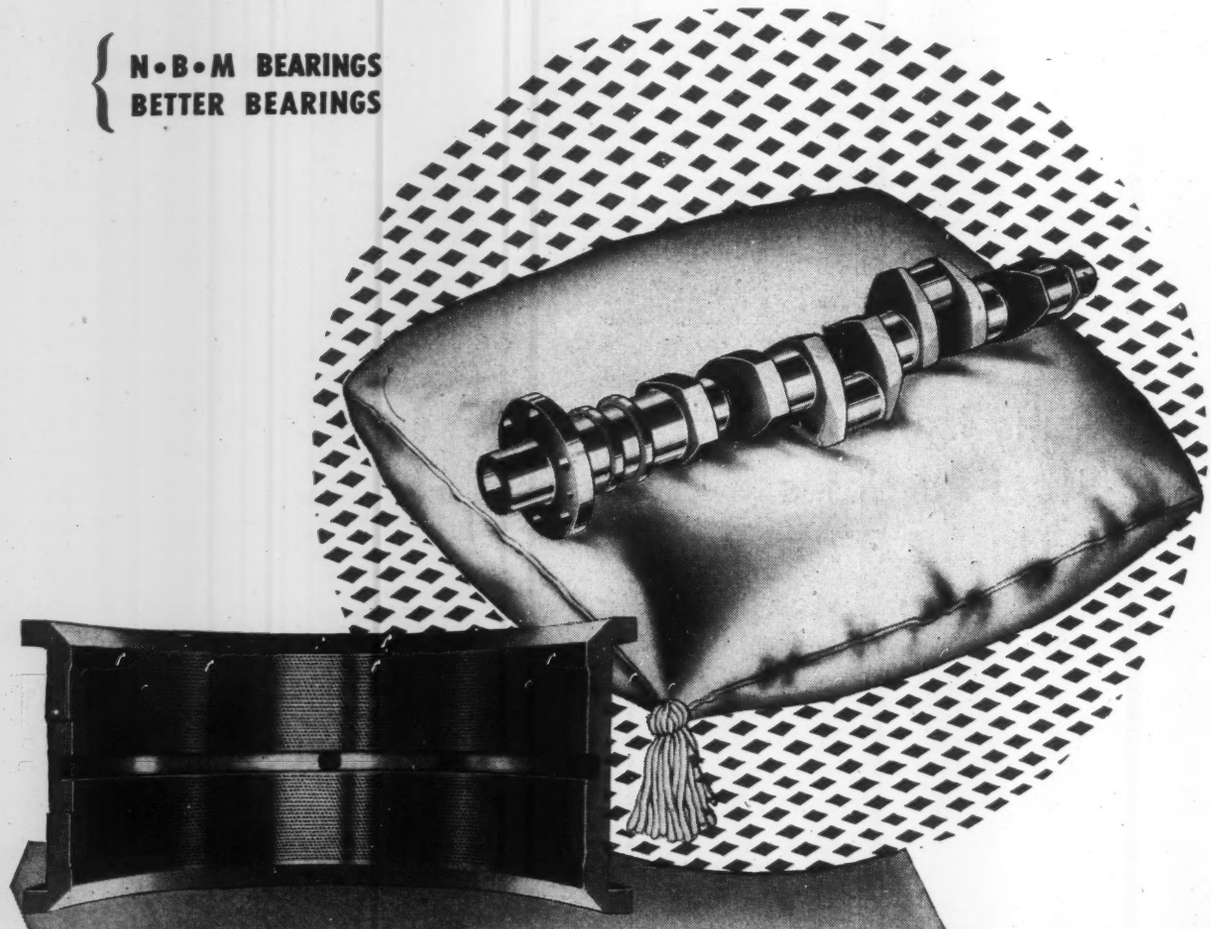
Lisle Magnetic Plugs can be used effectively in any product in which gears and bearings operate in a bath of oil. Used in place of an ordinary drain or oil level plug, the Lisle Plug contains a powerful magnet which attracts and holds iron and steel particles which wear off moving parts and circulate in the lubricant. Repeated tests have proved that removal of this abrasive substantially increases the life of bearings and other vital parts. You are invited to test Lisle Magnetic Plugs in your product without cost or obligation. Write today!



Lisle Magnetic PLUGS

Manufactured by LISLE CORPORATION
Box 1003 Clarinda, Iowa

{ N•B•M BEARINGS
BETTER BEARINGS



# N•B•M GRIDDED BEARINGS –A *Cushion* FOR SHAFT DEFLECTION

A multitude of precision-spaced grids, filled with N-B-M Silver Babbitt, form a protective "cushion". It provides plenty of "give" to conform to shaft deflection and covers up unevenness and destructive grit.

This interlocked bi-metallic construction gives Centrifugally Cast N-B-M Gridded Bearings greatly increased resistance to fatigue, seizure, and overstress in high-speed, heavy-load machinery where maximum safety is needed.

Write today for complete engineering data.

NBM

Brake Shoe

NATIONAL BEARING DIVISION
ST. LOUIS • NEW YORK

PLANTS IN: ST. LOUIS, MO. • PITTSBURGH, PA. • MEADVILLE, PA. • JERSEY CITY, N. J. • PORTSMOUTH, VA. • ST. PAUL, MINN. • CHICAGO, ILL.

# HELPFUL LITERATURE

## FOR DESIGN EXECUTIVES

### 1. Bearings & Rod Ends

Heim Co.—16-page illustrated bulletin No. 11 is descriptive of Heim Unibal spherical bearings and spherical bearing rod ends. Specifications and engineering data are given on these antifriction units for use in wide range of equipment.

### 2. Timing Apparatus

Haydon Mfg. Co.—12-page illustrated catalog No. 312 describes timing motors and apparatus for incorporation in equipment and machines. Details of motor and gear unit are shown. Elapsed time indicators, fixed interval repeat cycle timers, reset timers and time delay reset timers are typical of units. Applications of timers and clock movements are listed.

### 3. Panel Meters

Shurite Meters—2-page illustrated bulletin F-64 lists specifications and net prices of wide range of alternating and direct current ammeters, voltmeters and resistance meters. Mounting dimensions are given.

### 4. Motors & Generators

Burke Electric Co.—8-page illustrated bulletin No. GS contains data on fractional horsepower and induction motors, synchronous motors and generators, direct current motors and generators, motor-generator sets and terminal blocks. Alternating and direct current motors from 1 to 1500 horsepower and generators from 1 to 1000 kilowatts are discussed.

### 5. Wireway

National Electric Products Corp.—12-page illustrated revised catalog No. 445 describes 4 x 4-inch Wirewa enclosed metal duct for housing and protecting electric wires and cables. Component parts and installations of wireway within floor or directly to wall are shown.

### 6. Couplings

Farrel-Birmingham Co.—46-page illustrated bulletin No. 447 entitled "Farrel Gearflex Couplings" describes various types and operating principle of couplings for use in industrial and marine service. Recommendations of correct types for specific applications, ratings, dimensions and weights are included.

### 7. Filters

Skinner Purifiers, Inc.—4-page illustrated bulletin "Extra-Fine Filtration" is descriptive of model 3110-D Skinner general purpose filters with cleanable disk type elements. Details are given on units which will filter from ½ to 10 microns and will handle kerosene, gasoline, hydraulic oils, water, air and other fluids.

### 8. Nameplates & Dials

Maymer Corp.—4-page illustrated booklet discusses Syl-o-ette process for making scales, dials, templates, indicators, diagrams and nameplates up to 100 inches in length. Scales, both standard and special types, are produced on plain or coated flat surfaced metals, plastics and other stable surfaces while nameplates are engraved in laminated plastic.

### 9. Mechanical Tubing

Republic Steel Corp., Steel & Tubes Div.—8-page illustrated booklet discusses Electrunite electric welded mechanical tubing which is available in wide range of sizes, gages and analyses. Applications, fabricating advantages, sizes, ranges and properties of tubing are covered.

### 10. Selenium Rectifiers

Federal Radio & Television Corp.—Multiple-bulletin portfolio "FTR Selenium Rectifier Ideas" contains complete technical and application data on miniature five-plate selenium rectifiers. Claimed features of these units include improved voltage regulation, voltage multiplication, efficient rectification, instantaneous starting and handling of heavy transient overloads.

### 11. Fasteners

American Institute of Bolt, Nut & Rivet Manufacturers—20-page illustrated periodical entitled "Fasteners" Vol. 3 No. 5 contains data covering bolts, nuts, rivets and screws. Various contributed articles discuss "Riveting Aluminum Ships," "Rolling of Screw Threads," "How to Get Fasteners Quickly" and other aspects in fastener field.

### 12. Brooder Thermostat

Mu-Switch Corp.—1-page illustrated bulletin presents data on snap-action brooder thermostat for automatic control of temperature in electrically heated incubators and brooders. Unit is bakelite enclosed thus protecting the contacts from dust, feathers and corrosive atmospheres. List price is also included.

### 13. Motor Service

Westinghouse Electric Corp.—12-page illustrated booklet No. B-3711 gives details of motor exchange, shop repair and national service plans for servicing fractional horsepower motors. Booklet tells who is entitled to use these plans, how they operate and what can be accomplished when properly used.

### 14. Fluid Drive

American Blower Corp., Hydraulic Coupling Div.—24-page illustrated bulletin No. 7419 presents data on Gyrol fluid drive especially designed for electric motors. Drive operates on hydro-kinetic principle, transmitting power solely by vortex of oil. Characteristics, applications, data for selection, shaft arrangements, specifications and typical installations are shown.

### 15. Angle & Offset Valves

Parker Appliance Co.—4-page illustrated booklet shows and describes forged brass angle and offset valves manufactured with either triple flared tube fitting ends or pipe threads, or both. Construction features, engineering data and specifications are included.

### 16. Snap Action Switches

Acro Electric Co.—2-page illustrated bulletin entitled "Convert Your Switch Design to Acro Snap Action" shows various models of snap action switches. Open blade switch assemblies in gangs which are used in coin-operated machines are covered.

### 17. Flexible Joints

Barco Mfg. Co.—Catalog sheets No. 350 and No. 209 describe Barco flexible ball-swivel and revolving joints for use on airplanes and flexible ball joints for handling fluids and gases where flexible conveyor is required. Dimensional data and typical applications are shown.

### 18. Piercing & Riveting

Mueller Engineering Co.—4-page illustrated bulletin "New Era Hydraulic Piercing With Automatic Hydraulic Stripping" describes piercing and riveting units and machines. Details are given also on line of hydraulic cylinders.

### 19. Flexible Shafts

S. S. White Dental Mfg. Co., Industrial Div.—12-page illustrated bulletin No. 4501 lists basic information and application data on flexible shafts for remote control and for power drives. Construction details, characteristics, selection factors and other information are given.

---

FIRST CLASS
PERMIT No. 36
(Sec. 510 P.L.&R.)
Cleveland, Ohio

**BUSINESS REPLY CARD**
No Postage Stamp Necessary if Mailed in the United States

4c POSTAGE WILL BE PAID BY—

**MACHINE DESIGN**
Penton Building
*Reader's Service Dept.* CLEVELAND 13, OHIO

---

**MACHINE DESIGN** 3-47
1213 West Third St., Cleveland 13, Ohio

| | | | | |
|---|---|---|---|---|
| 1 | 11 | 21 | 31 | 41 |
| 2 | 12 | 22 | 32 | 42 |
| 3 | 13 | 23 | 33 | 43 |
| 4 | 14 | 24 | 34 | 44 |
| 5 | 15 | 25 | 35 | 45 |
| 6 | 16 | 26 | 36 | 46 |
| 7 | 17 | 27 | 37 | 47 |
| 8 | 18 | 28 | 38 | 48 |
| 9 | 19 | 29 | 39 | 49 |
| 10 | 20 | 30 | 40 | 50 |

*Please have literature circled at left sent to me.*

NAME _____ TITLE _____

COMPANY _____

MACHINES MANUFACTURED _____

ADDRESS _____

CITY AND STATE _____

*This card MUST be completely filled out. Please TYPE or PRINT.*

## 20. Air Conditioning

Taylor Instrument Cos.—44-page illustrated catalog No. 5 is descriptive of company's line of instruments for air conditioning, heating and ventilating. Controllers, hygrometers, valves, interrupters, pilot valves, thermometers, barometers, anemometers and various other instruments are covered.

## 21. Wire, Strip & Bars

American Steel & Wire Co.—64-page illustrated reference manual covers gages, sizes, weights and lengths of round wire, cold finished bars and cold rolled strips. Available in steel, iron, copper and aluminum, wire is produced in diameters from 1 inch to 0.000878-inch.

## 22. Gear Shaving

National Broach & Machine Co.—4-page illustrated bulletin No. S-46-7 is entitled "Shaving Greatly Facilitates Camshaft Gear Production." Typical case study of gear shaving shows advantages of using this method of gear finishing.

## 23. Magnesium Forgings

Wyman-Gordon Products Corp.—12-page illustrated booklet is descriptive of magnesium and comparative properties of alloys of magnesium, aluminum and steel. In addition, statistics on company's 18,000-ton press are listed.

## 24. Induction Motors

Century Electric Co. — 8-page illustrated bulletin No. 643 gives design, operating and application information on line of slip ring induction polyphase motors rated from 1 to 350 horsepower. Designs are available for wide range of purposes.

## 25. Flexible Couplings

Industrial Machine Works—4-page illustrated bulletin gives details of three-piece gear-tooth flexible coupling available in broad range of standard bore sizes from ¼ to 1¾ inches. Specifications and typical applications are shown.

## 26. Small Gears

Gear Specialties—4-page illustrated bulletin describes many different types of small gears ranging from 12 to 96 diametral pitch and discusses possible applications.

## 27. Piston Type Pumps

Vickers Inc.—28-page illustrated bulletin No. 43-11 describes Vickers piston type pumps for variable delivery hydraulic power systems. Capacities are from 3 to 340 gallons per minute. Construction features, specifications, types of controls, dimensional data and typical circuit diagrams are shown.

## 28. Centrifugal Switch

Euclid Electric & Mfg. Co.—4-page illustrated bulletin describes centrifugal switch used to plug motors to quick stop by application of reverse power. Switch improves efficiency and safety of machine tools and other industrial machinery.

## 29. Motors & Generators

Electric Specialty Co. — 8-page illustrated catalog No. 46-1 is descriptive of rotating electrical equipment which includes special motors, generators, motor-generator sets, converters and other units. Both alternating and direct current equipment are covered.

## 30. Hydraulics

Adel Precision Products Corp. — 28-page illustrated booklet entitled "The Principles of Basic Hydraulics" discusses hydraulic power as applied to present day products. Description, flexibility of arrangements and applications of hydraulic systems are covered.

## 31. Window Units

Bijur Lubricating Corp.—4-page illustrated bulletin No. 4-B presents data on self-contained, one-piece window units for indicating liquid level, flow or drip and for observation of position or movement of parts, such as gear mesh, timing marks and others. Window is clear, hard, unbreakable plastic which will not cloud up.

## 32. Plastic Molding

Chicago Molded Products Corp.—26-page illustrated brochure entitled "The Story of Plastic Molding" discusses types of plastic materials, recommended applications of plastics and methods of fabrication and sets forth information helpful to plastic parts buyers. Advantages of company's custom molding service are described.

## 33. Springs

Accurate Spring Mfg. Co.—36-page illustrated handbook on spring design and application covers design formulation procedure and tables as well as load deflection tables and other data. Tables of wire diameters, gages and other information are presented for use of design engineers.

## 34. Protective Coating

United Chromium, Inc.—4-page illustrated folder gives properties, application data and typical uses of Ucilon protective synthetic coating which resists severe corrosive conditions. Especially adaptable for maintenance work, this coating was developed from improved, inert, synthetic resins.

## 35. Steam, Line Equipment

Johnson Corp.—Illustrated condensed bulletin No. 232 presents information on rotary pressure joints, pressure equalizing boiler feed pumps, automatic boiler water controls, Electrap for boiler feed or lift service, steam operated water heaters and air and steam separators. Typical installations are diagrammed.

## 36. Surface Analyzer

Brush Development Co.—4-page illustrated booklet entitled "A New Aid for Industry in Surface Finish Control" describes rough-finish measuring head which consists of BL-101 drive head and BL-102 pickup. Unit checks rough finishes of 100 to 3000 microinches. Specifications, technical features and prices are given.

## 37. Plastic Sealant

American Cyanamid Co., Plastics Div.—4-page illustrated bulletin discusses advantages of Laminac resin as sealant for porous metal castings which must be pressuretight. Methods of impregnating castings are described in detail and schematic drawings are shown.

## 38. Pumps

Robbins & Myers, Inc.—16-page illustrated bulletin No. 1903-A presents details of Moyno pump for handling products ranging from free-flowing materials to nonpourable pastes. Performance data, specifications, application information and design and construction details are covered.

## 39. Oil Purifiers

Honan-Crane Corp. — 4-page illustrated bulletin shows how use of Honan-Crane oil purifiers prevents excessive wear of hydraulic pump parts and minimizes repairs on hydraulic presses, machine tools, balers, injection molding machines and other units employing hydraulic oils.

## 40. Oil & Water Coolers

Ross Heater & Mfg. Co.—2-page illustrated bulletin No. 5022 is descriptive of type BCF No. 212 lubricating oil and jacket water cooler for small cooling requirements. Performance charts and dimensions of this unit, constructed entirely of brass and bronze, are presented.

## 41. Film Storage

Eastman Kodak Co.—16-page booklet entitled "Storage of Microfilms, Sheet Films and Prints" is guide for storage of safety film base and paper base materials only. Pamphlet discusses required protection; classification of records; short term, moderate term and archival storage; fire protection; preparation for storage and storage temperature.

## 42. Pulleys & Couplings

Congress Die Casting Div.—4-page illustrated bulletin presents information on diamond bored die cast V-grooved, combination grooved, V-step cone and variable pitch pulleys and flexible couplings for wide range of applications. Dimensional and specification data are included.

**MACHINE DESIGN** 3-47
**1213 West Third St., Cleveland 13, Ohio**

| | | | | |
|---|---|---|---|---|
| 1 | 11 | 21 | 31 | 41 |
| 2 | 12 | 22 | 32 | 42 |
| 3 | 13 | 23 | 33 | 43 |
| 4 | 14 | 24 | 34 | 44 |
| 5 | 15 | 25 | 35 | 45 |
| 6 | 16 | 26 | 36 | 46 |
| 7 | 17 | 27 | 37 | 47 |
| 8 | 18 | 28 | 38 | 48 |
| 9 | 19 | 29 | 39 | 49 |
| 10 | 20 | 30 | 40 | 50 |

***Please have literature circled at left sent to me.***

NAME _____ TITLE _____

COMPANY _____

MACHINES MANUFACTURED _____

ADDRESS _____

CITY AND STATE _____

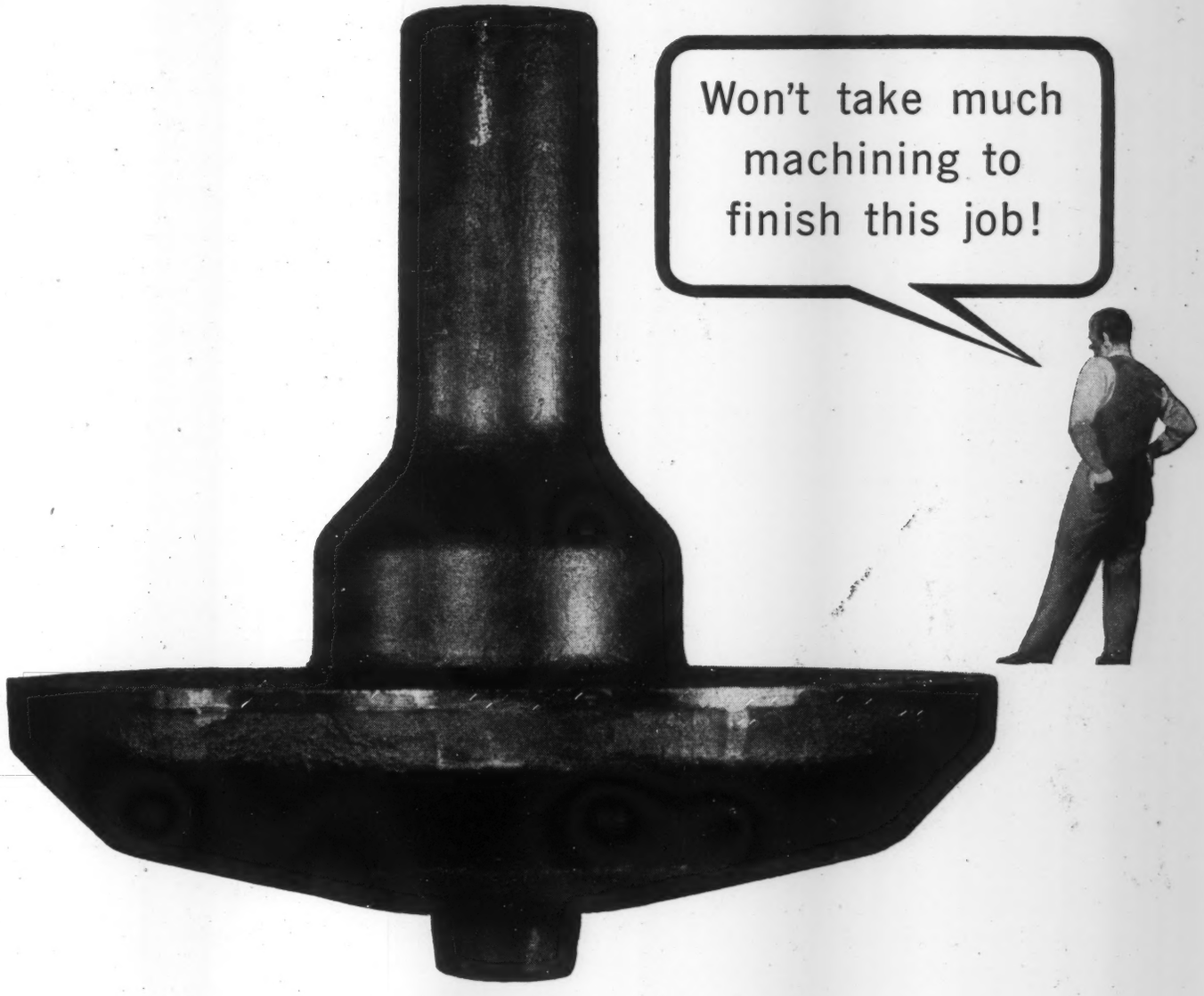
***This card MUST be completely filled out. Please TYPE or PRINT.***

**FIRST CLASS PERMIT No. 86 (Sec. 510 P.L.&R.) Cleveland, Ohio**

**BUSINESS REPLY CARD**
**No Postage Stamp Necessary if Mailed in the United States**

**4c POSTAGE WILL BE PAID BY—**

**MACHINE DESIGN**
**Penton Building**
**Reader's Service Dept.** **CLEVELAND 13, OHIO**




## Unretouched photo of Tube Turns forging right off the press

A really good forging reduces machining requirements to a minimum . . . saves man hours and cuts repair costs on machines and excessive replacement costs of machine tools.

In this case TUBE TURNS' engineers and die designers took the customer's drawings, worked out a forging operation to bring the part as forged close to machined tolerances. The forgings were mass-produced without excess metal, on a high-speed mechanical press. Machining was greatly reduced. The customer got better forgings and saved money—in pounds of raw metal required, manpower needed to finish the job, and in wear and tear on machine tools.

Are you looking for good forging service on "round jobs" of this type? Get in touch with:

**TUBE TURNS (Inc.) LOUISVILLE 1, KENTUCKY**

District Offices at New York, Washington, D. C., Philadelphia, Pittsburgh, Detroit, Chicago, Houston, San Francisco, Los Angeles.

**TUBE TURNS** tt Forgings for Industry

# RITCO

## MACHINED FORGINGS and UPSETS

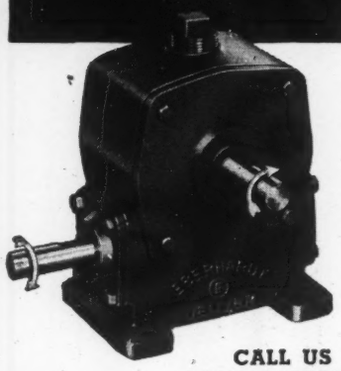
Where accuracy and maximum strength are essential, you can rely on RITCO drop and upset forgings. Smooth and free of flash, they are produced in steel or non-ferrous metals, from ¼ lb. to 15 lbs. in accordance with your blueprints. Our equipment for finishing—machining, grinding and assembling—is complete and modern. Estimates gladly submitted.

**REMEMBER RITCO FOR**
DROP AND UPSET FORGINGS
COMPLETE MACHINING FACILITIES
SPECIAL BOLTS, NUTS AND STUDS
MILLED BODY BOLTS

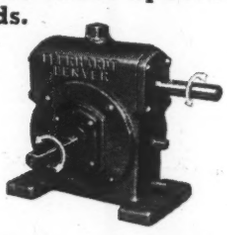
**RHODE ISLAND TOOL CO.**
148 WEST RIVER STREET
P. O. BOX 1516, PROVIDENCE 1, R. I.

***Serving American Industry Since 1834***

# *Speed Reducers* FROM STOCK



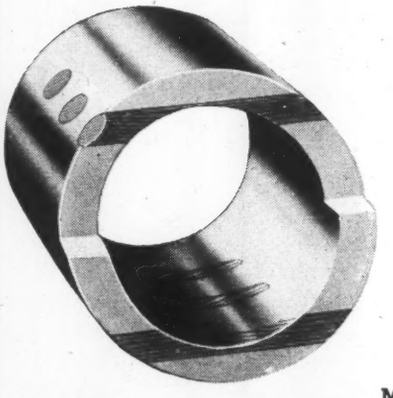
**Manufactured in a practical range of sizes and reductions. We also build reducers to meet special needs.**



**CALL US LONG DISTANCE**

**Eberhardt-Denver Co.**
GEARS AND SPEED REDUCERS
1416 West Colfax Ave., Denver 4, Colorado Phone TAbor 7134

# . . . JUST TRY 1



## MOCCASIN BUSHING

*on your most*

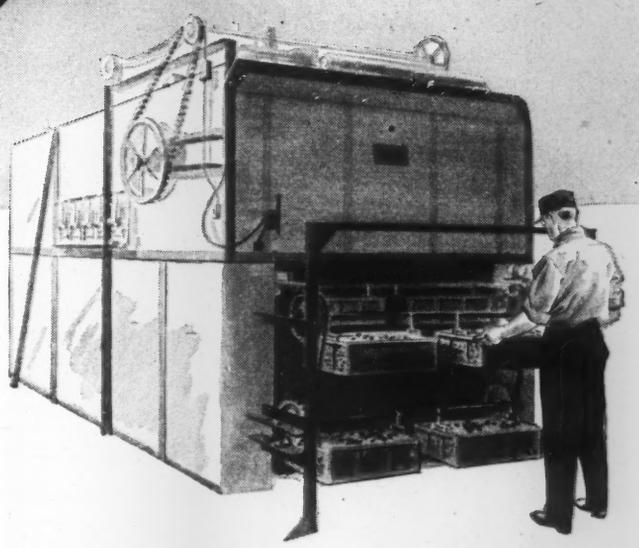
**TROUBLESOME BEARING**

The success of Moccasin Bushings' efficiency lies in their unique lubrication principle. Oil is drawn from a reservoir in the bearing housing and is distributed by capillary action in a continuous, unbroken film over the entire bearing surface. Drippage and seepage of oil is entirely eliminated, and under ordinary circumstances they require attention only two to four times a year—just try one on your most troublesome bearing. Guaranteed for satisfactory service. Write for folder No. 428 showing nine other styles of bushings.

***Moccasin***
**BUSHING COMPANY**
**CHATTANOOGA TENNESSEE**

# WAA OFFERS AT LOW COST

# Industrial Ovens



Baking and drying ovens, of specifications, sizes and types in common use but which today are not readily available, can now be purchased for prompt delivery from the War Assets Administration. Regardless of your specialized requirements, the odds are in favor of your needs being satisfied from this extensive surplus stock. Prices are so low that ovens may be converted from their original use when this is desirable and still permit a substantial saving to the purchaser.

There are ovens for the following uses: for baking lacquer, enamel, synthetic resin, japanning, for low temperature metal heat treating, for drying and curing chemicals, rubber, paper, lithographing, plastics, ceramics, etc.

Principal inventories are located at: Boston, Chicago, Cincinnati, Cleveland, Minneapolis, New York, Philadelphia, Richmond, St. Louis. Write the above Regional Offices requesting that your name be placed on their mailing lists for this type of surplus.

All furnaces offered subject to prior sale.

ALL FURNACES are sold under existing priority regulations. VETERANS OF WORLD WAR II are invited to be certified at the War Assets Administration Certifying Office serving their area, and then to purchase the materials offered herein.

EXPORTERS: Your business is solicited. If sales are conducted at various levels, you will be considered as a wholesaler. Any inquiries regarding export control should be referred to Office of International Trade, Department of Commerce, Washington, D. C.

***See our display booth***
***at Western Metal Exposition and Congress Show***
***at Oakland, California, March 22 to 27, 1947.***

OFFICE OF GENERAL DISPOSAL

## WAR ASSETS ADMINISTRATION

GOVERNMENT WAA SURPLUS

**Offices located at: Atlanta • Birmingham • Boston • Charlotte • Chicago • Cincinnati • Cleveland • Dallas Denver • Detroit • Fort Worth • Helena • Houston • Jacksonville • Kansas City, Mo. • Little Rock • Los Angeles • Louisville • Minneapolis • Nashville • New Orleans • New York • Omaha • Philadelphia • Portland, Ore. • Richmond • St. Louis • Salt Lake City • San Antonio • San Francisco • Seattle • Spokane • Tulsa**

838-3

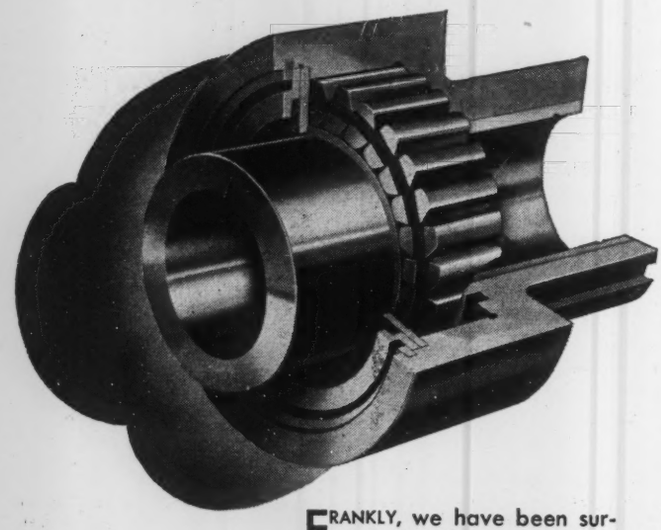
We learn something every day

ABOUT

FORMSPRAG

THE FULL COMPLEMENT

Over-Running Clutch



FRANKLY, we have been surprised to find there are so many different applications for Formsprag. We knew we had an outstanding product that would deliver high torque in a limited space, that would cut in and out hundreds of times a minute, that engaged positively and silently, that operated without backlash or vibration.

But we had no idea of the hundreds of different types of applications that Formsprag is now handling efficiently.

In manufacturing these many types it has been necessary to build Formsprag in many sizes and capacities, until we are now tooled up to produce a wide range of standard sizes, from 240 to 123,000 inch-pounds theoretical torque, in either plain or ball bearing types.

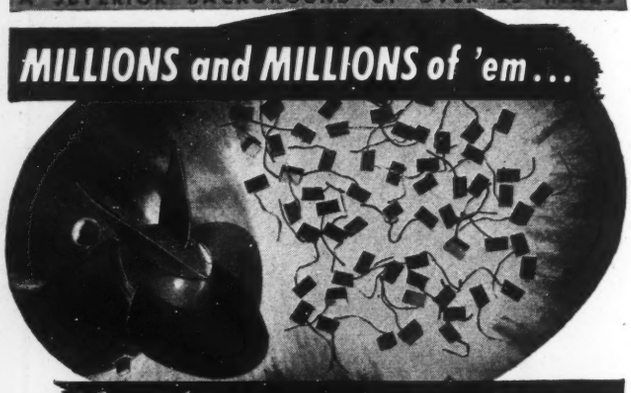
If you have, or think you may have an application, why not talk it over with us?

FORMSPRAG Company

1415 JARVIS • FERNDALE, MICH.

A SUPERIOR BACKGROUND OF OVER 25 YEARS

MILLIONS and MILLIONS of 'em...



Superior BRUSHES for AUTOMOTIVE HEATING and DEFROSTING EQUIPMENT

By this time we're safe in believing them to be a success for specific applications. What are *your* requirements? Perhaps our Research Department can develop for you a metal graphite or other type of brush that will deliver better service for the same money or equal service for less money, or better service for less money. Why not write us today?

SUPERIOR CARBON PRODUCTS, INC.

9117 George Ave., Cleveland 5, Ohio

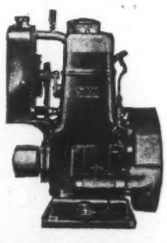
"Since 1919" SUPERIOR CARBON BRUSHES

WITTE DIESEL UNITS

FOR PROFIT-MAKING LIGHTING AND MACHINE-DRIVING POWER

With every feature of their simple, compact design engineered to produce maximum power at minimum cost, WITTE Diesel Engines and Dieselectric Plants keep on giving reliable service years after returning their original small cost. Safe for operation in confined places. Require no specialized mechanical skill to install, nor expert care.

*Start and Run on Ordinary, Readily Available Diesel Fuel*



Being full Diesels, WITTE Diesel Engines and Dieselectric Plants deliver full power output on low-cost Diesel fuel—the same safe fuel on which they start. Before you decide on any new equipment, write us for descriptive literature and recommendation of the WITTE Diesel power unit to meet your exact needs. Engine sizes 4 to 12 H.P.; Dieselectric Plants 3 to 10 KVA. Every WITTE Diesel unit is fully tested at factory, for power performance, and shipped complete, ready for immediate use.

WITTE ENGINE WORKS

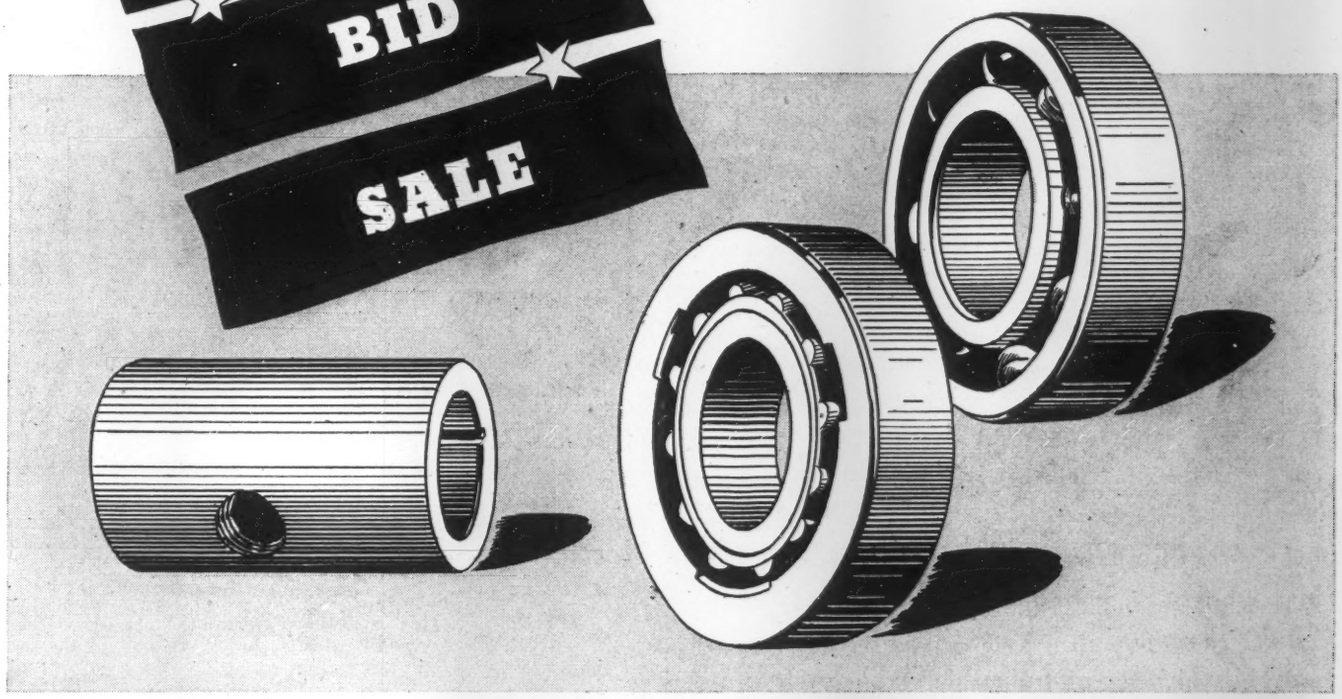
DIVISION OF OIL WELL SUPPLY COMPANY — UNITED STATES STEEL CORPORATION SUBSIDIARY

LARGEST BUILDER OF SMALL DIESELS

KANSAS CITY 3, MO., U.S.A.

# SEALED BID SALE

# BEARINGS



You can't go wrong when you get your bearings from the $23,000,000 stock now being sold by WAA. Friction and anti-friction bearings and components—all sizes and types—all unused and in top condition. Set your own price on what you need. Your nearest WAA Regional Office will give you all pertinent information on the sale and will assist you to make an inspection before submitting your bid.

*Sales of Bearings will be held at frequent intervals. To receive information on future sales, write to the Regional Offices listed below asking that your name be placed on their mailing lists.*

**BOSTON · CINCINNATI · CHICAGO · CLEVELAND**
**ST. LOUIS · LOS ANGELES**

★ ★ ★

OFFICE OF GENERAL DISPOSAL

## WAR ASSETS ADMINISTRATION

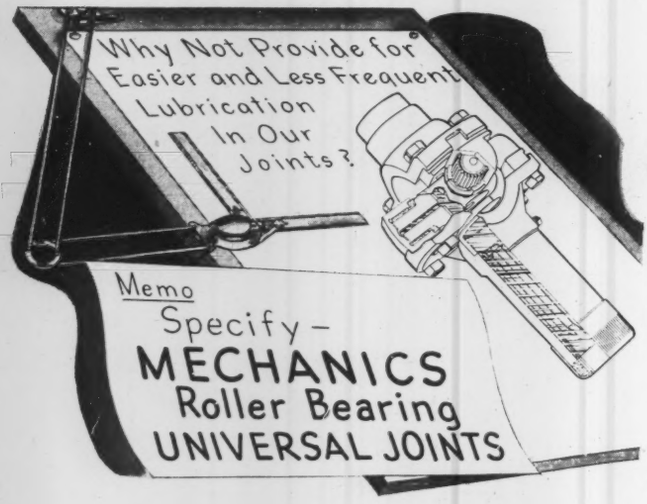
GOVERNMENT WAA SURPLUS

**Offices located at: Atlanta • Birmingham • Boston • Charlotte • Chicago • Cincinnati • Cleveland Dallas • Denver • Detroit • Fort Worth • Helena • Houston • Jacksonville • Kansas City, Mo. • Little Rock Los Angeles • Louisville • Minneapolis • Nashville • New Orleans • New York • Omaha • Philadelphia Portland, Ore. • Richmond • St. Louis • Salt Lake City • San Antonio • San Francisco • Seattle • Spokane • Tulsa**

1021

## What Would You Do About A Problem Such As This?

**INTER-OFFICE MEMO:**
The universal joints in our 194X model must provide for better, easier and less frequent lubrication

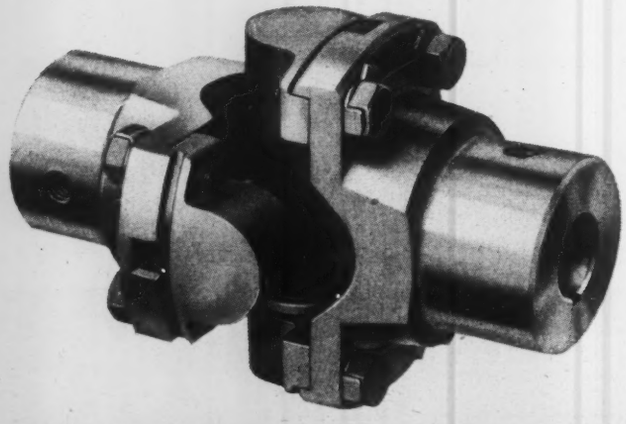



MECHANICS design permits generous, long-lasting lubrication — without disassembling. One "shot" through a convenient oil plug hole in the cross fills the reservoir from which lubricant is forced to all four bearings.

Another "shot" fills the slip-yoke chamber.

Efficient seals prevent leakage and keep out dirt and moisture.

Let our engineers show you how this and other MECHANICS advantages will benefit your new models.



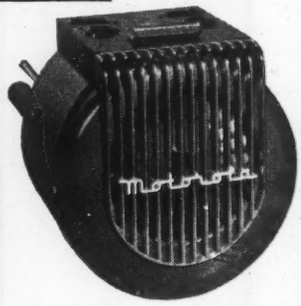
MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2026 Harrison Ave., Rockford, Ill.



# FOR PROFITABLE ASSEMBLY

*Let* **TINNERMAN** *analyze your fastening problems*

**BEFORE You Leave the "Mock-up" Stage**




**Just as the Galvin Manufacturing Corp. did with their new Motorola Auto Heater**

To take full advantage of the SPEED NUT System, Galvin engineers sat right in with Tinnerman development engineers who planned the assembly of the new Motorola Heater while it was still in the "mock-up" stage. 14 different types of SPEED NUTS and SPEED CLIPS were used with big savings. The result was assembly perfection.

This engineering service is available to you, too — at no cost. Check the SPEED NUT System of Fastening before you go into production.

**TINNERMAN PRODUCTS, INC., 2085 Fulton Rd., Cleveland 13, O.**

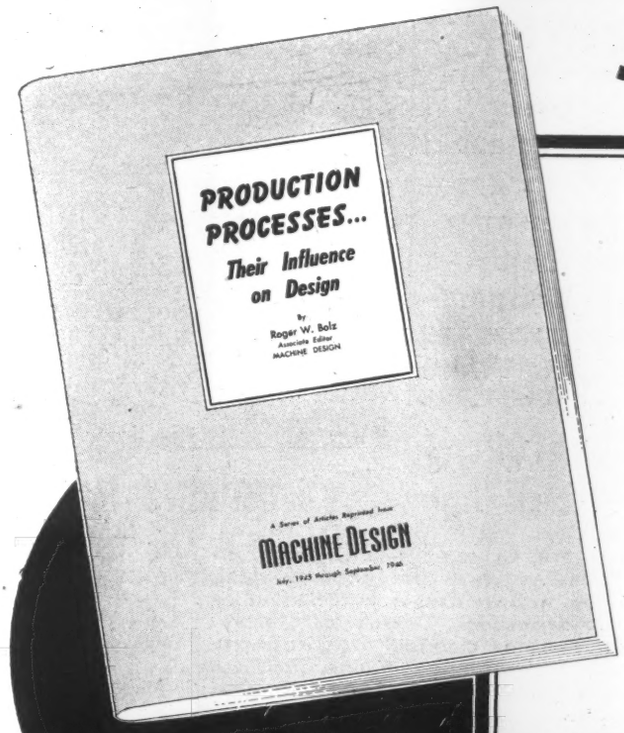
*Write for our new Bulletin No. 214 on this Motorola Job. The fastening ideas illustrated should be helpful to you.*

Speed Nuts* — FASTEST THING IN FASTENINGS
MORE THAN 4000 SHAPES AND SIZES — PATENTED — *Trade Mark Reg. U.S. Pat. Off.

One of more than 40 different types and sizes of Miniature Ball Bearings
RADIAL • PIVOT • ANGULAR CONTACT • THRUST
*PROMPTLY AVAILABLE* — *ASK FOR CATALOG 1*

MPB MINIATURE *Precision* BEARINGS
INCORPORATED
KEENE, NEW HAMPSHIRE, U.S.A.

# Just Off the Press!




PRICE $1.00* POSTPAID
100 PAGES
PROFUSELY ILLUSTRATED

# PRODUCTION PROCESSES...

## THEIR INFLUENCE ON DESIGN

By Roger W. Bolz
Associate Editor, MACHINE DESIGN

IMPORTANCE of mass production processing methods relative to their tremendous influence upon practical, economical and satisfactory design is gaining wide recognition. Design changes to simplify and reduce the cost of manufacture after release of parts to the shop are usually costly and often cause undue delays. To assist the designer in evaluating the various processing methods available and help in achieving the advantages of maximum economy, accuracy and speed in the manufacture of tomorrow's machines, a series of articles are appearing currently in MACHINE DESIGN. The first fifteen parts, listed at the left, are now available as a bound volume.

### 15 CHAPTERS OF PRODUCTION PROCESSES

- BROACHING
- SPINNING
- SCREW MACHINING
- DIE FORGING
- TURRET LATHE MACHINING
- STAMPING
- DEEP DRAWING
- SWISS AUTOMATIC MACHINING
- GEAR SHAPER GENERATING
- ROLL FORMING
- CONTOUR SAWING
- FLAME CUTTING
- COLD HEADING
- SECTION CONTOUR FORMING
- SHOT PEENING

*Order your copy today—use the convenient order form below.*

MACHINE DESIGN, Book Department
Penton Building, Cleveland 13, Ohio

Please send ..... copies of "PRODUCTION PROCESSES" at $1.00* per copy. (Discount on quantity orders, prices on request.)

☐ Payment is enclosed.
☐ Send invoice to company as shown below.

Name ..... Title .....

Company .....

Address .....

City ..... Zone ..... State .....

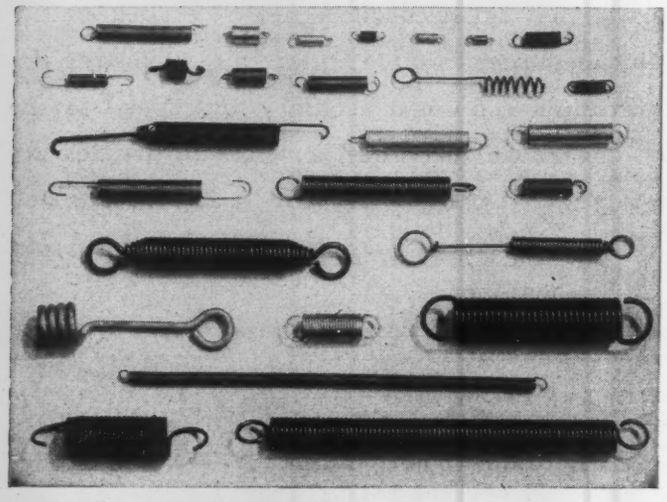
* Please add 3% state sales tax on orders for delivery in Ohio

Reliable

You may have learned by bitter experience that it is mistaken economy to regard springs as a mere incidental in product design. Frequently the failure of the spring alone means the failure of the whole mechanism. There are so many variables to take into account, that these factors can only be correlated by qualified spring experts.

Why not save time, trouble, and expense involved in guessing and rule-of-thumb methods? Reliable can give you valuable assistance in accurately designing the spring to suit the working space and the function. By installing new equipment—four-slides, power benders, coiling and grinding machines—we have added 25% to our productive capacity, to serve you better and faster on all types of springs, wire forms, spring stampings. We have pleased so many exacting customers, that we ought to be able to please you too.

*When sending inquiry, describe springs as completely as possible, sending sketch, samples, or blue print. Mention any special requirements known, such as working space, initial tension, and load. Show, if possible, on every spring drawing the spring itself, in solid lines, and the mating parts or surfaces, preferably in assembled position, in dotted lines. Bulletin on request.*

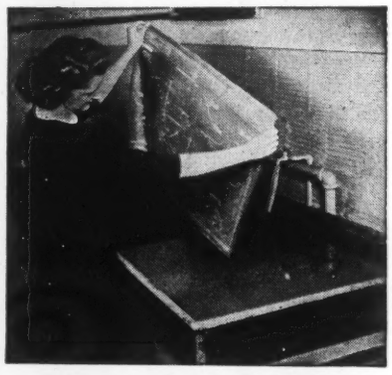


**THE RELIABLE SPRING & WIRE FORMS CO.**
**3167 Fulton Road** **Cleveland 9, Ohio**
*Representatives in Principal Cities*

YOU CAN RELY ON
**Reliable Springs**
ROUND AND FLAT WIRE SPRINGS · CLIPS · HOOKS · BENDS · LIGHT STAMPINGS

# HI-TENSED Blueprints

[ Replacing Potash ]
**Are Sharper—Clearer**
**Hold Color Longer—**
**SOLUTION IS NON-STAINING NON-CORROSIVE**



**OPERATOR IS Protected Against "BLUEPRINT RASH"**

**Hands can be completely immersed in *Hi-Tense Concentrate* Blueprint Developing Solution without danger of irritation or caustic dermatitis. Doesn't stain equipment, walls or clothing. Non-corrosive to tank, equipment or plumbing. Produces exceptionally sharp, clear blueprints. Pint bottle makes 40 gallons of solution. Consistently used by leading industrial concerns. Try a case of 6 bottles at $8.10. Order from your drafting supply jobber—or *direct*, if he can't supply you.**

**WISCONSIN PHARMACAL CO.**
**221 N. Water Street, Milwaukee 2, Wis.**

Two IMO pumps employed for supplying hydraulic pressure oil to a combustion control system

THE DE LAVAL-IMO PUMP is a rotary, positive displacement pump of unique design having *only three moving parts* — a power rotor and two idler rotors. Pump output is uniform at all pressures, making an ideal unit for hydraulic, fuel and governor services.

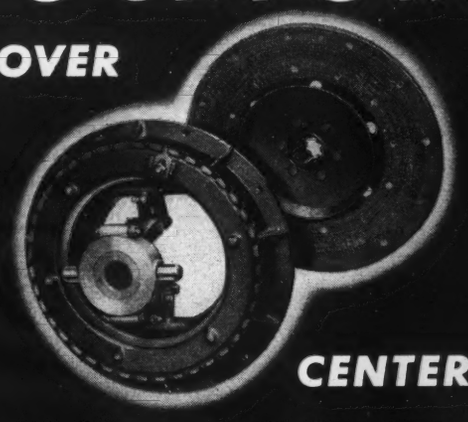
*For further information ask for catalog I-136.—D*

IMO means I MOVE OIL

IMO PUMP DIVISION of the
DE LAVAL STEAM TURBINE CO.
TRENTON 2, NEW JERSEY

# ROCKFORD

OVER



CENTER

# CLUTCHES

EASY OPERATION
HIGH TORQUE
POSITIVE ENGAGEMENT
LARGE DRIVING AREA
SMOOTH RUNNING
INFREQUENT ADJUSTMENT
MINIMUM INERTIA

* ROCKFORD Over-Center CLUTCHES are carefully balanced to prevent drag or centrifugal force from affecting their smooth running operation. An electronic gauge accurately checks the balance of each ROCKFORD Over-Center CLUTCH, within extremely close limits, before it passes final inspection.

**Send for This Handy Bulletin**

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD CLUTCH DIVISION BORG-WARNER
311 Catherine Street, Rockford, Illinois, U. S. A.

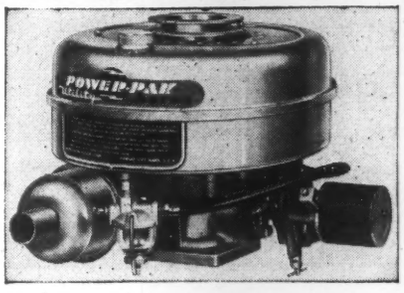


*Power It with...*

# POWER-PAK

GASOLINE UTILITY MOTOR

- 2 hp. at 4000 rpm.
- Precision-Built
- Light Weight
- Compact
- Rugged




**DESIGNED TO MEET MODERN DEMANDS!**

*H*ere's a modern-to-the-minute, precision-built, gasoline motor especially fitted to the needs of industrial designers and manufacturers making machines and equipment requiring 2 H. P.

POWER-PAK is compactly designed, light weight (only 19 lbs.), every piece and part of finest materials to insure long, smooth, trouble-free operation. Overall length 14¾", width of cowling 9½", height 8$\frac{1}{16}$". Easily installed . . . economical on fuel . . . easy access to all vital parts. Replacement parts always in stock. Let POWER-PAK solve your power problem.

**AVAILABLE NOW . . . GET FULL FACTS**

*Write today for Illustrated Literature, full details and prices on the POWER-PAK.*

**PROPULSION ENGINE CORP.**

**Dept. 1077, 7th and White Eagle Road, Kansas City, Kans.**

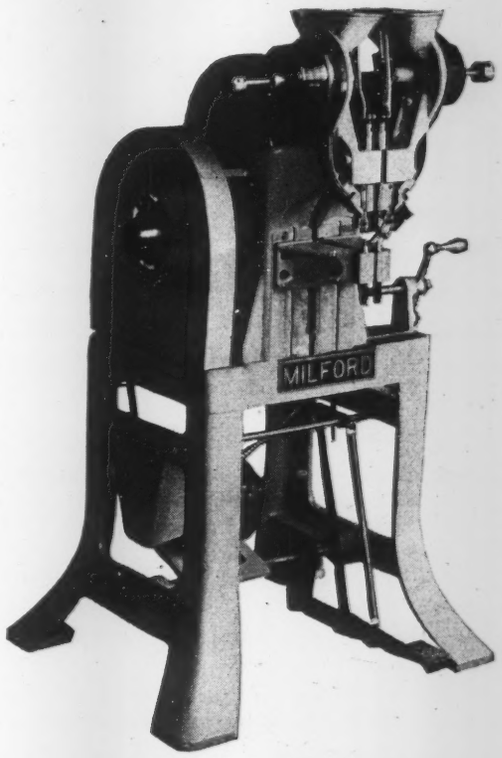


MILFORD FASTENING EQUIPMENT

**MODEL NO. 55DP DOUBLE SPINDLE RIVET SETTER**

# SETS 2 RIVETS AT ONE TIME

*120 a Minute*




**FOR ASSEMBLIES OF**
Cutlery Handles
Small Locks
Name Plates
Radio Chassis
Electrical Parts
Clock Cases • Toys
and a wide variety
of similar products

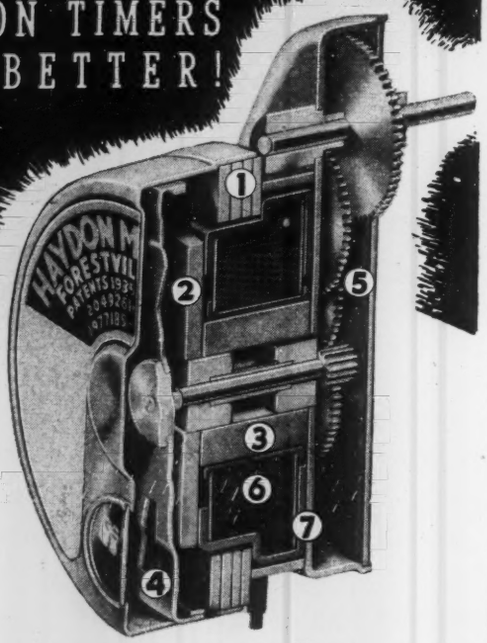
**Milford manufactures 15 standard rivet setters, designs and manufactures rivets in endless variety. Call Milford for suggestions on assembly operations to cut costs, save time, increase profits.**

**THE MILFORD RIVET & MACHINE CO.**
855 Bridgeport Ave. MILFORD, CONN.
996 West River St. ELYRIA, OHIO

*Inquiries may also be addressed to our subsidiary:*
THE PENN RIVET & MACHINE CO., PHILADELPHIA 33, PENNA.

*Designers and Manufacturers of:* SPECIAL COLD-HEADED PARTS; SPLIT, SEMI-TUBULAR AND DEEP-DRILLED RIVETS; RIVET-SETTING MACHINES; SPECIAL MACHINE SCREWS AND SCREW MACHINE PARTS.

# SEE... WHY HAYDON TIMERS ARE BETTER!




This cross section of a Haydon timer illustrates a few of the many patented features that have made them the most accurate and efficient in the field.

1 **Shading coil construction gives high starting torque.**

2 **Field structure gives balanced torque characteristics.**

3 **Projection-welded core produces better magnetic field and rugged construction.**

4 **Uniform reluctance ring rotor for uniform torque characteristics, rigidly held by spun-over support.**

5 **Lubricant carried by capillary attraction to each gear assembly; irrespective of mounting position of unit.**

6 **Coil sealed against moisture, tested for 2000 VAC breakdown.**

7 **Projection-welded field assures accurate air gap and rugged construction.**

Write for the new HAYDON catalog for details of this and other HAYDON timers.

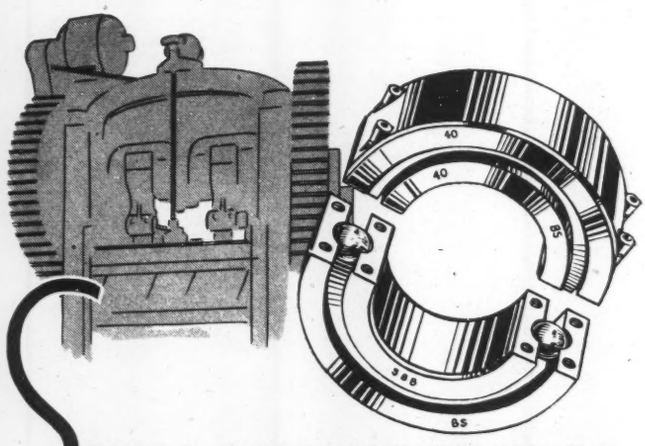
TIMING ENGINEERING SERVICE

**Haydon**

MANUFACTURING COMPANY • INCORPORATED •

*Forestville, Connecticut*

SUBSIDIARY OF GENERAL TIME INSTRUMENTS CORPORATION



# SPLIT BALLBEARINGS *Save Down-time!*

When machine tools, process equipment, pumps, etc. are down for repairs, SPLIT BALLBEARINGS can save tremendous down-time costs and reduce to a minimum production bottle-necks.

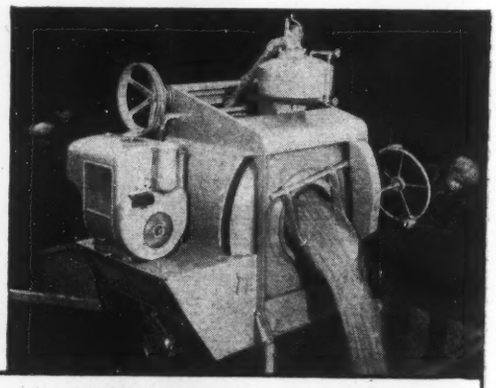
Investigate the time-saving and cost-reducing advantages of SPLIT BALL and ROLLER BEARINGS in your new designs and important redesigns. Latest catalog on request. Ask for bulletin MD-347.

·DIVISIBLE RACE BEARINGS·

**SPLIT BALLBEARING CORPORATION**

LEBANON, NEW HAMPSHIRE. U. S. A.

**POWER CERTAINTY**



***Provided by* WISCONSIN**
**Heavy-Duty *Air-Cooled* ENGINE**

The Kwik-Mix 11-S Dandie, made by Kwik-Mix Company, Port Washington, Wis. (Koehring Subsidiary), not only has a reputation for fast charging, fast discharge and quick re-mixing . . . but it is also noted for *Power Certainty* . . . the ability to keep on going day after day, in any weather, anywhere.

This is a logical result of heavy-duty power delivery by the Model VE-4 (V type, 4 cylinder) Wisconsin Air-Cooled Power Unit which turns up 20.5 hp. at 2200 R.P.M. Incorporated in this engine are features of Heavy-duty design pioneered by Wisconsin . . . assuring maximum serviceability on the job and minimum maintenance costs.

For Power Certainty . . . regardless of the kind of equipment you are using . . . specify "Wisconsin Air-Cooled Engines" . . . for any machine or job within a 2 to 30 hp. range. Descriptive literature on request.

Most H.P. per pound

**WISCONSIN MOTOR**
Corporation
MILWAUKEE 14, WISCONSIN, U. S. A.
*World's Largest Builders of Heavy-Duty Air-Cooled Engines*

Direct acting diaphragm type pressure reducing valves developed for use as component parts of equipment where space is a determining factor.

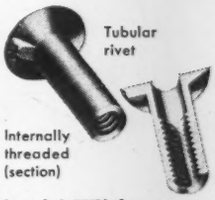
Bulletin No. 199 gives more details. ..... It's free on request.

Manufacturing SPECIALISTS OF
CASH-ACME
Automatic PRESSURE CONTROL VALVES

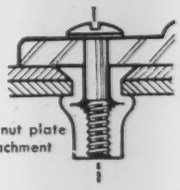
A.W. CASH VALVE MFG. CORP.
6614 EAST WABASH AVE.
DECATUR ILLINOIS

# SIMPLE RIVNUT FASTENING

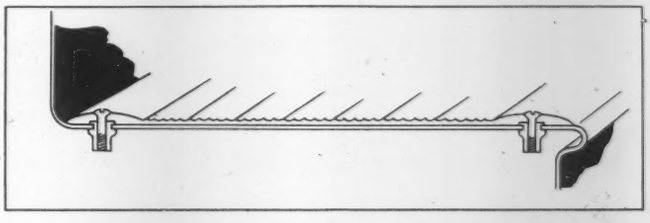
## *Speeds Production — Cuts Costs*



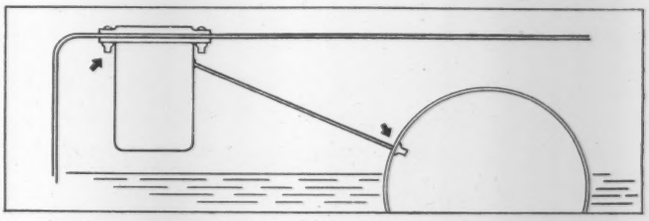

These unique one-piece blind fasteners have many time-, labor-, and money-saving advantages. B. F. Goodrich Rivnuts are strong, light, low cost. Easy to fasten with...fasten to...or both! With easy-to-operate tool, Rivnuts are pulled up or headed while working entirely from one side, forming a bulge on the blind side. They are used in wood, metal or plastics. Many sizes, types and grips are available in steel, brass, aluminum and splined aluminum.




# RIVNUTS solve these problems this way—*perhaps they can help you*



Rivnut S10-75. Used as a nut plate to fasten rubber step plate on automobile door steps. Fast, labor-saving operation.

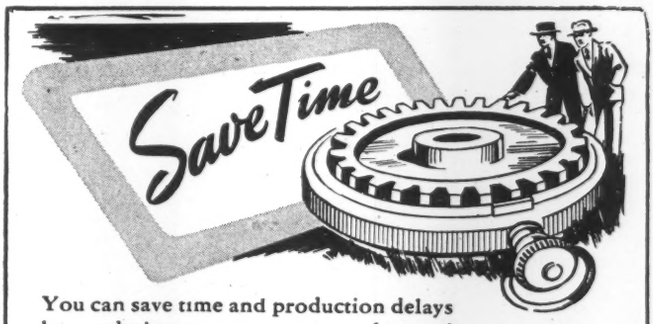


In an automobile's gas tank, a BR 10-B45 blind end Rivnut seals the ball, provides threads for the stud. Installation is simple, fast.

### FREE "RIVNUT DATA BOOK"

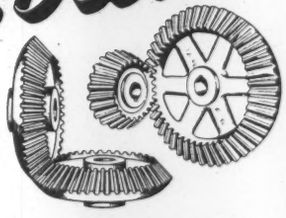
*All the facts at your fingertips in 40 illustrated pages. How Rivnuts are installed, uses, types, sizes, strength, tools, test data. Write to the B. F. Goodrich Company, Dept. MD 37, Akron, Ohio.*

**B.F.Goodrich**
**RIVNUTS**
*It's a rivet—It's a nutplate*




You can save time and production delays by ordering your gears, racks and sprockets from "Industrial". You will get "on time" deliveries.

"Industrial"



### GEARS CUT AND FINISHED TO YOUR REQUIREMENTS

Our large modern plant is fully equipped with the finest machinery available for gear production. We have open machine time in our internal and external grinding departments and can also take care of your precision surface grinding. Whatever your needs consult "Industrial" Engineers.

*Make it a habit to send us your order.*

INDUSTRIAL GEAR MFG. CO.
4529 VAN BUREN STREET CHICAGO 24, ILLINOIS

# New KINNEY *High Speed* CLUTCH

Exploded view of High Speed Enclosed Type Clutch.

The new Kinney Enclosed Type Clutch—symmetrical in design and perfectly balanced—gives outstanding performance at relatively high speeds up to 4000 R.P.M. Special Velvetouch friction surfaces engage without strain or grabbing; when disengaged, the clutch is free from drag and does not waste power. Counterbalanced thrust fingers are specially designed to make disengagement positive at high speed. Adjustment is readily made at a single point through threaded case-front. This Clutch allows maximum slippage while picking up the load, without lowering the capacity when fully engaged. Enclosed model available in capacities from 1 to 10 HP per 100 R.P.M.; open construction 6 to 30 H.P. Prices upon request. Write for information.

**KINNEY MANUFACTURING COMPANY**

**3569 WASHINGTON ST., BOSTON 30, MASS.**

NEW YORK • CHICAGO • PHILADELPHIA • LOS ANGELES • SAN FRANCISCO

***We also manufacture Vacuum Pumps, Liquid Pumps and Bituminous Distributors.***

# This is it!

**New Filter Cleans Oil!**

**3-times more filtering surface**

## the MARVEL Synclinal FILTER

*Don't let idle machines break the back of your production schedule.* By actual laboratory test, this remarkable sump-type liquid unit keeps pump, cutting tools and cylinders moving because it operates at three-times greater capacity—permits a higher rate of oil flow at less pressure.

**REVOLUTIONARY SYNCLINAL INSERT...**

with multi-surfaced corrugations of re-inforced wire cloth offer far greater filtering surface—gives longer, trouble-free operation. Openings are .0050". Inserts with smaller or larger apertures available. Boost production on oil re-circulating machines. Write for price list and descriptive folder.

**DISTRIBUTORS WANTED—Choice territories available. Write for particulars.**

**MARVEL ENGINEERING COMPANY**

**69 W. Washington, Dept. 10, Chicago 2, Ill.**

# ZEROL GEARS

**To Your Exact Specifications**

**For smoother, quieter operation wherever straight bevel gears are conventionally used**

**Write for Bulletin on Gear Jobbing Service —Our Specialty for More Than 30 Years**

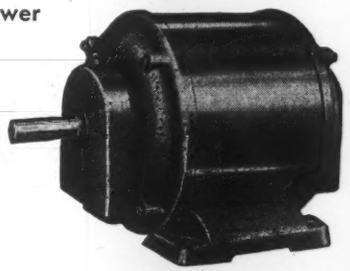
**DETROIT BEVEL GEAR CO.**

8130 JOS. CAMPAU • DETROIT 11, MICH.

*Before you specify*

**ANY MOTOR,** *check these* **VALLEY** *ADVANTAGES*

- ✓ **Wide Adaptability**—sizes ½ to 75 h. p.
- ✓ **More Flexibility** in power planning.
- ✓ **Takes Unusual** Power Loads
- ✓ **Drip-Proof . . .** Splash-Proof
- ✓ **Economical** Operation
- ✓ **Cool**
- ✓ **BALL BEARING**



**VALLEY**
**ELECTRIC CORPORATION**
4221 Forest Park Blvd. • St. Louis 8, Mo.

AUSTRALIAN AGENT: .....Paul & Gray, Ltd., Sydney
SCANDINAVIAN AG'T: Aktiebolaget C. E. Johansson, Eskilstuna, Sweden

There is almost limitless use for Mall Remote Control Flexible Shafting in starting, stopping, indicating and regulating distant motions. Valves and skylights can be opened and closed . . . temperatures of buildings, furnaces and ovens regulated . . . machine speeds indicated on tachometers . . . vehicle speeds indicated on speedometers . . . flood lights turned to desired position . . . hands set on clocks and many other applications where positive control of clockwise and counter-clockwise motion is desired. Mall Remote Control Flexible Shafting can be furnished to your specifications—in any length or type with Metallic or Elastic Plastic covered housings and almost any combination of ends which may be splined, square, flat or threaded and made of any desired material.

*Over 25 years of designing, engineering and precision manufacturing experience assures correctness of design and high reliability. Write at once, giving full details of your remote control problem. Our Engineering Staff is at your disposal.*

**FLEXIBLE SHAFT DIVISION**
**MALL TOOL COMPANY**
**7731 South Chicago Ave., Chicago, Illinois**
★ *26 Years of "Better Tools For Better Work"*

Mall REG. U.S. PAT. OFF. **PORTABLE POWER TOOLS**

# 475 Machine Tools MEANS CAPACITY PRODUCTION WITH Brad Foote Gears

**CUT GEARS**

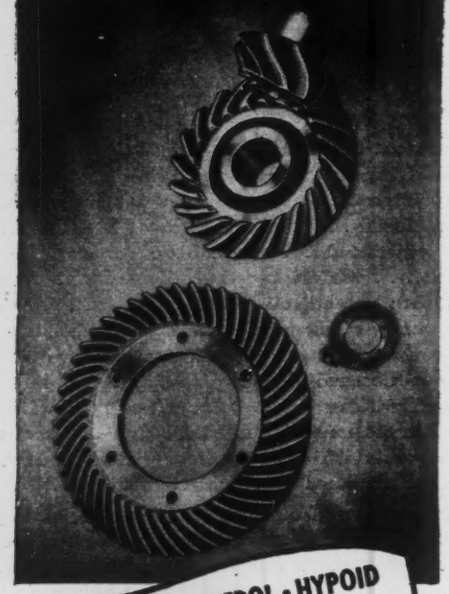
ALL SIZES • WORM • SPUR
HELICAL • HERRINGBONE
SPIRAL • STRAIGHT BEVEL
HYPOID • ZEROL • SPIRAL
BEVEL

**SPEED REDUCERS**

Any Ratio • All Horsepowers

**RATIOS**

| | |
|---|---|
| Herringbone | 2:1 to 295:1 |
| Worm | 3⅝:1 to 60:1 |
| Gyro | 24:1 to 3600:1 |
| Spur | 2:1 to 40:1 |
| Vertical Helical | 2:1 to 80:1 |
| Spiral Bevel | 1:1 to 5:1 |
| Planetary | 4:1 to 400:1 |
| Oil Well Units | 12:1 |
| Little Giant | 28:1 |

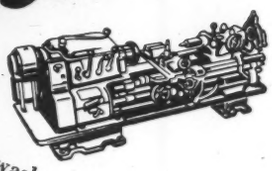


**SPIRAL BEVEL • ZEROL • HYPOID**
Diameters ¾ inch and 24 Diametral Pitch—To—Approx. Diameters 32 inch and 1½ Diametral Pitch.

*Write for Descriptive Literature*

**BRAD FOOTE GEAR WKS.**
1315 South Cicero Avenue
CICERO 50, ILLINOIS

BEARING
# LOCKNUTS AND LOCKWASHERS



Locknuts and Lockwashers for ball and roller bearings—S. A. E. Standard—A. B. E. C. Standard—Heavy-duty and Specials. Locknuts in sizes N-00 through AN-40. Lockwashers (all new multi-prong type) in sizes W-00 through W-40.

An inquiry will bring you complete information on Standard Locknuts and Lockwashers . . . orders will be given immediate attention.

**REQUEST OUR SPECIFICATION BULLETIN No. 27-C**

**Standard Locknut & Lockwasher, Inc.**
33 West St. Clair Street — Indianapolis 4, Indiana

# COMMERCIAL STAMPINGS

The finest of modern equipment operated by men long skilled in maintaining quality standards in quantity production has built for Commercial Stampings a wide-spread reputation for genuine quality . . . in materials, in workmanship and in finish. We engineer and produce all of our own dies and tools, assuring accuracy in the finished product as well as economy in cost. Commercial specializes in contract stampings of the medium and heavy types. Buy Commercial Quality Stampings . . . they add increased value to your product at less cost. Improve the quality of your product with quality stampings.

The COMMERCIAL SHEARING AND STAMPING COMPANY
YOUNGSTOWN 1, OHIO

# STROM BALLS *for the Bearings of Industry*

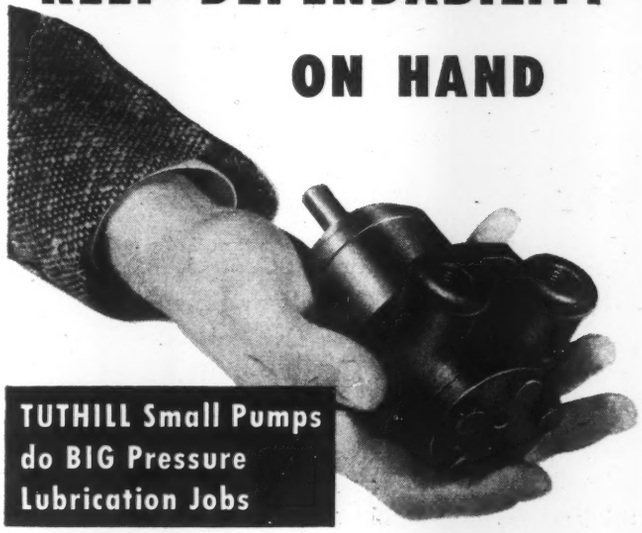
*Balls being ejected from normalizing furnaces during process of heat treating*

Industry continually seeks to perfect the performance of its products. That means that all parts must be brought up to higher and higher standards. It is especially important that the balls on which the bearings of industry run shall be of the highest standard of perfection. Strom Balls, in their unbelievably high qualities of finish, sphericity and precision—developed through exclusive concentration on making fine balls for 25 years—hold first place in American industry. Strom Steel Ball Co., 1850 So. 54th Avenue, Cicero 50, Illinois.

**Strom BALLS Serve Industry**

LARGEST INDEPENDENT AND EXCLUSIVE METAL BALL MANUFACTURER

# KEEP DEPENDABILITY ON HAND



**TUTHILL Small Pumps do BIG Pressure Lubrication Jobs**

For all its small size, the Tuthill Model L pump does a whale of a job in pressure lubrication and hydraulic service. This internal-gear rotary pump is mechanically sealed and built in capacities up to 3 g.p.m. in pressure ranges up to 400 p.s.i. Ring or foot mounting. Many porting arrangements. Write for bulletin on Tuthill small industrial pumps.

***TUTHILL PUMP COMPANY***
939 East 95th Street, Chicago 19, Illinois

# VALVAIR WON'T LEAK AFTER *Millions* OF OPERATIONS!

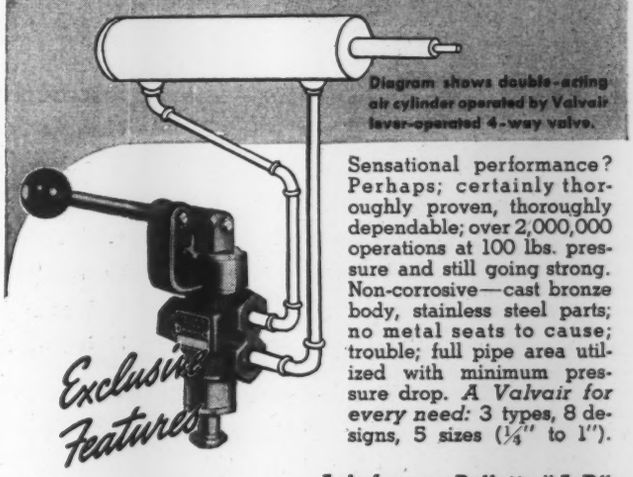


Diagram shows double-acting air cylinder operated by Valvair lever-operated 4-way valve.

Sensational performance? Perhaps; certainly thoroughly proven, thoroughly dependable; over 2,000,000 operations at 100 lbs. pressure and still going strong. Non-corrosive—cast bronze body, stainless steel parts; no metal seats to cause; trouble; full pipe area utilized with minimum pressure drop. *A Valvair for every need:* 3 types, 8 designs, 5 sizes (¼" to 1").

*Exclusive Features*

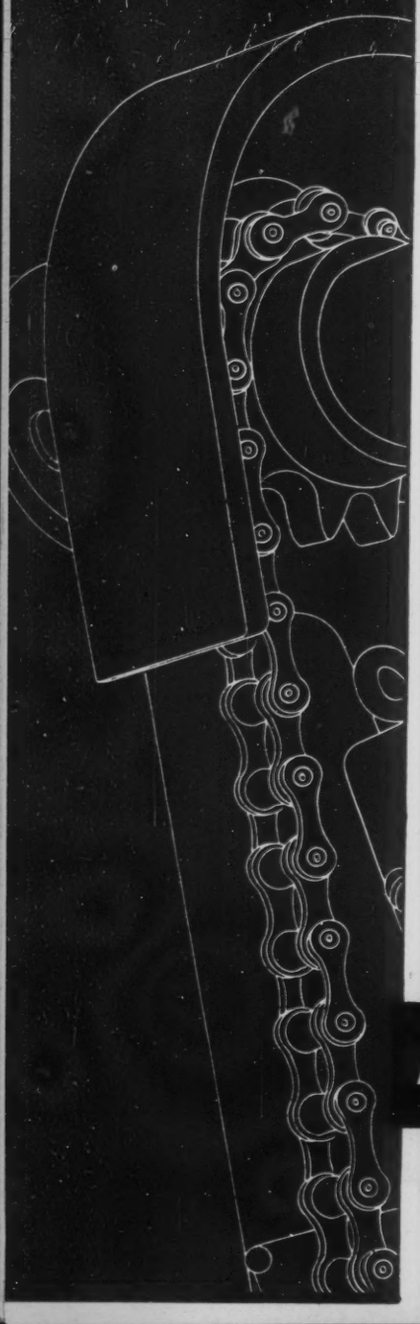
***Ask for our Bulletin "A-D" or a Valvair representative***

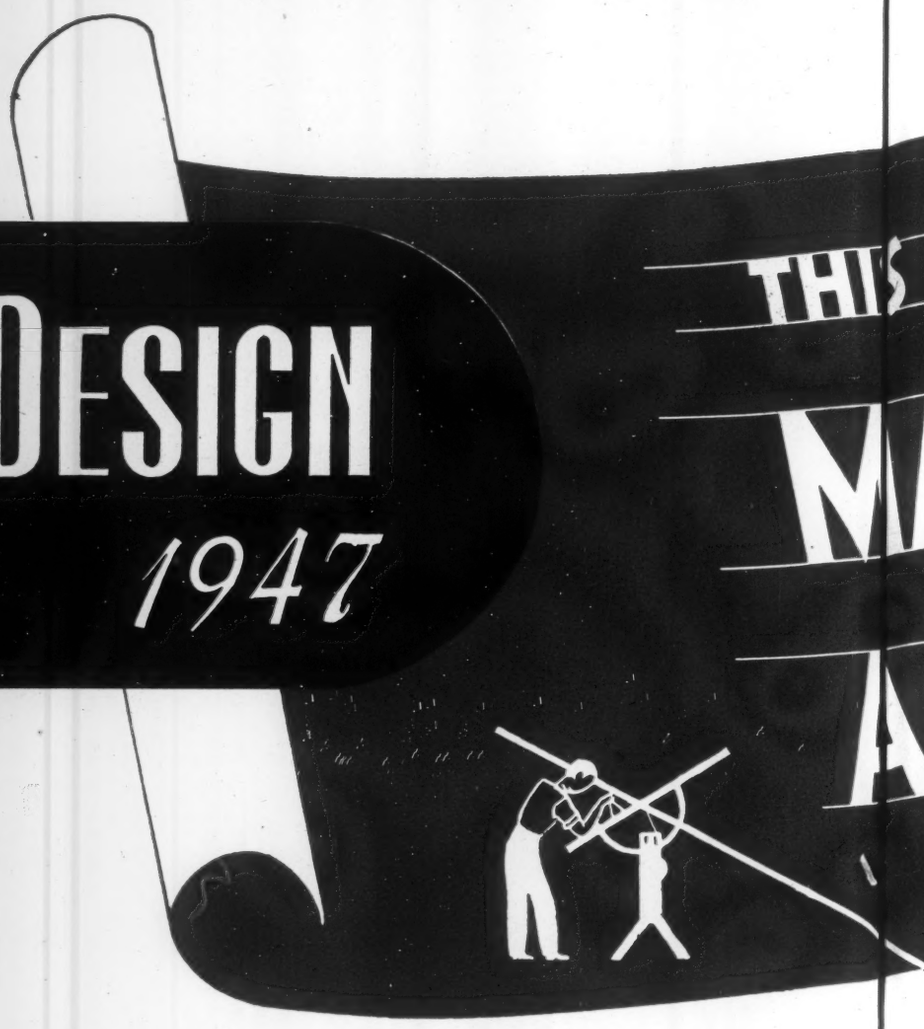
**VALVAIR CORPORATION • 454 Morgan Avenue, Akron 11, Ohio**

**Valvair**

# MACHINE DESIGN

*April* *1947*



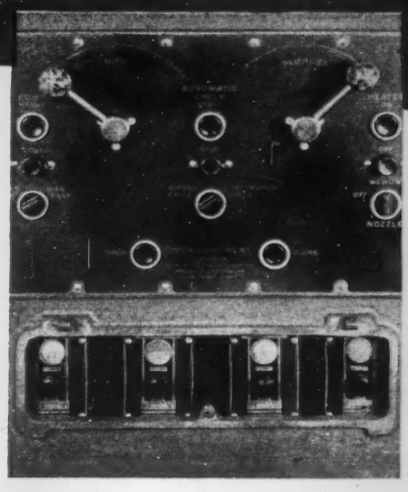



## EDITORIAL FEATURES

Selection of Motors—Automatic Presetting of Controls—Unusual Gear Drives—Interlocking Control Systems—Torsional Vibration Dampers for Power Drive—Automatic Power Controls—Coupling and Clutch Applications—Electronic Controls—Electromagnetic Drives—Remote Controls—Solenoid-Operated Mechanisms—Hydraulic Drives and Controls—Pneumatic Power and Its Control—Drive and Control Features of Specific Machines.

**MACHINE DESIGN IS NOW READ BY MCR**

# IS ISSUE DEVOTED ENTIRELY TO MACHINE DRIVES AND CONTROLS



THE April issue of MACHINE DESIGN, bringing Design Engineers as it has for the past ten years a comprehensive roundup of all that's new in machine drives and controls, has become a standard reference work on these subjects.

MACHINE DESIGN editors, in collaboration with outstanding industrial design authorities will present in the April issue feature articles on developments over the past year in power transmission and control equipment used on all types of machines. These two subjects will be treated objectively so that every reader may have a clear picture of the latest advances.

This eleventh edition of MACHINE DESIGN on drives and controls will furnish you with the information necessary to specify the proper power and control units for your company's products. This April issue will prove of lasting value throughout the year as a reference and convenient source of information.

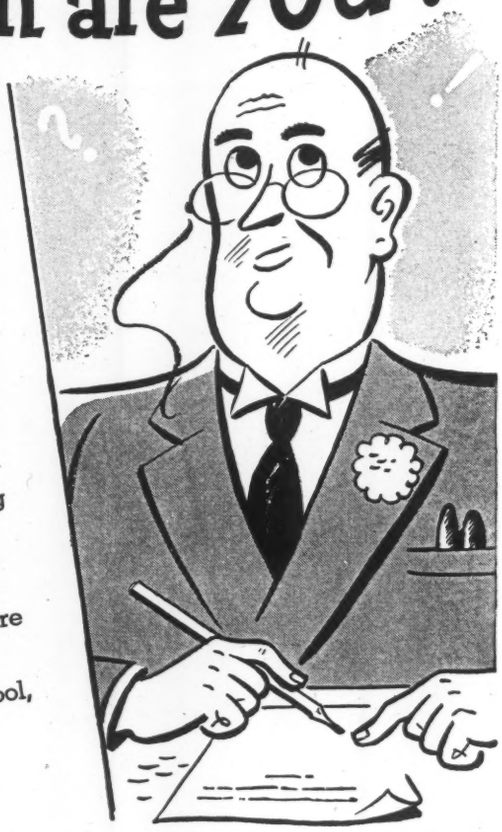
**ICRE THAN 50,000 DESIGN ENGINEERS EVERY MONTH**

# EXECUTIVES:

# How Good a Salesman are YOU?

## TEST YOURSELF WITH THIS PRODUCT—

### Guaranteed to Please Every Customer



**CHECK HERE** how many of your employees are buying U.S. Savings Bonds regularly

**HERE'S HOW YOU RATE** according to national averages

- ☐ **90%** or more ➡ No one needs to tell you anything about selling.
- ☐ **80%** or more ➡ Excellent.
- ☐ **70%** or more ➡ Not bad. Just apply a little more effort.
- ☐ **60%** or less ➡ This wasn't a high mark in school, either.

**The "PRODUCT"**—U. S. Savings Bonds—is easy to sell, because it offers every prospect a guaranteed means of making money. Each unit can produce $4 for every $3 of purchase price.

**The MARKET** consists of all your employees. It is an eager market, as shown by surveys—which indicate that 85% of all participants in the Payroll Savings Plan want the plan continued.

**The REWARD** is twofold: By helping your employees build personal security, you help assure that they will be happier, more stable—more productive on the job. And you help *all* of us, including yourself, because every Bond you sell helps to check inflationary tendencies.

## Are You Using These Booklets?

If not, or if you wish additional copies, just ask your State Director of the Treasury Department Savings Bonds Division.

**THE PEACETIME PAYROLL SAVINGS PLAN**—A booklet, published for key executives by the Treasury Department, containing helpful suggestions on the conduct of your payroll savings plan for U.S. Savings Bonds.

**THIS TIME IT'S FOR *YOU***—A booklet for employees . . . explaining graphically how the payroll savings plan works . . . goals to save for, and how to reach them with Savings Bonds.

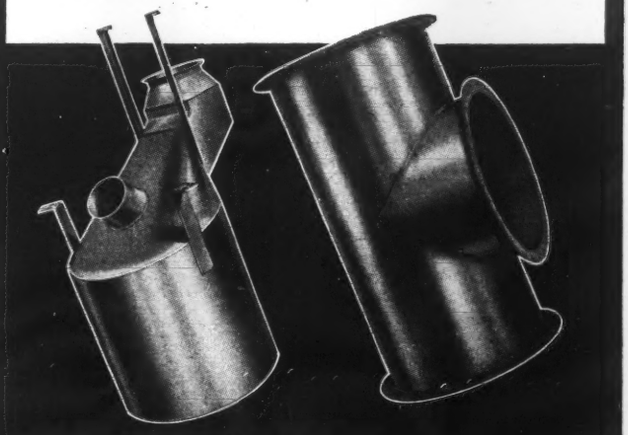
*The Treasury Department acknowledges with appreciation the publication of this message by*

## MACHINE DESIGN

*This is an official U. S. Treasury advertisement prepared under the auspices of the Treasury Department and The Advertising Council*

## GET QUALITY, PRECISION IN YOUR FABRICATING

For 66 years Littleford has fabricated plate and sheet steel products for American industry. Use this plant for precision forming, bending, welding, shearing, etc. Large job or small, simple or intricate, show blueprints to Littleford for free estimate.



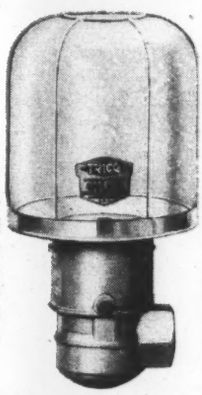
LITTLEFORD

LITTLEFORD BROS., INC.
424 E. Pearl St. Cincinnati 2, Ohio

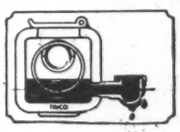


*Add these "plus values" to your machines with*

## TRICO OILERS

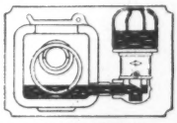


TRICO Opto-Matic Oilers automatically maintain an accurate, constant level of oil in ring and ball bearings. Maximum performance and bearing life are assured. Machine Builders everywhere specify TRICO OILERS for increased customer satisfaction and greater machine value.



THE OLD WAY

Bearings have either too much or too little oil. It's all guesswork!



THE NEW WAY

Oil level is accurately maintained automatically.

**ADD TRICO OILERS to your machines for these "plus values":**

- Guaranteed, accurate lubrication
- Protection against bearing failures
- No down-time for hand-oiling
- Up-to-date appearance
- Increased prestige
- Labor, power and oil saving
- Easy to install.

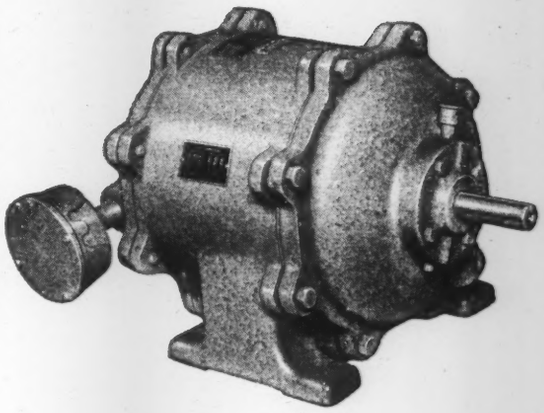
There's a type and style available for every application.

TRICO *Write for Catalog!*

TRICO FUSE MFG. CO., Milwaukee, Wis.
In Canada: IRVING SMITH LIMITED, Montreal



# HOW TO MIX SPARKS with GAS *without a* BOOM!

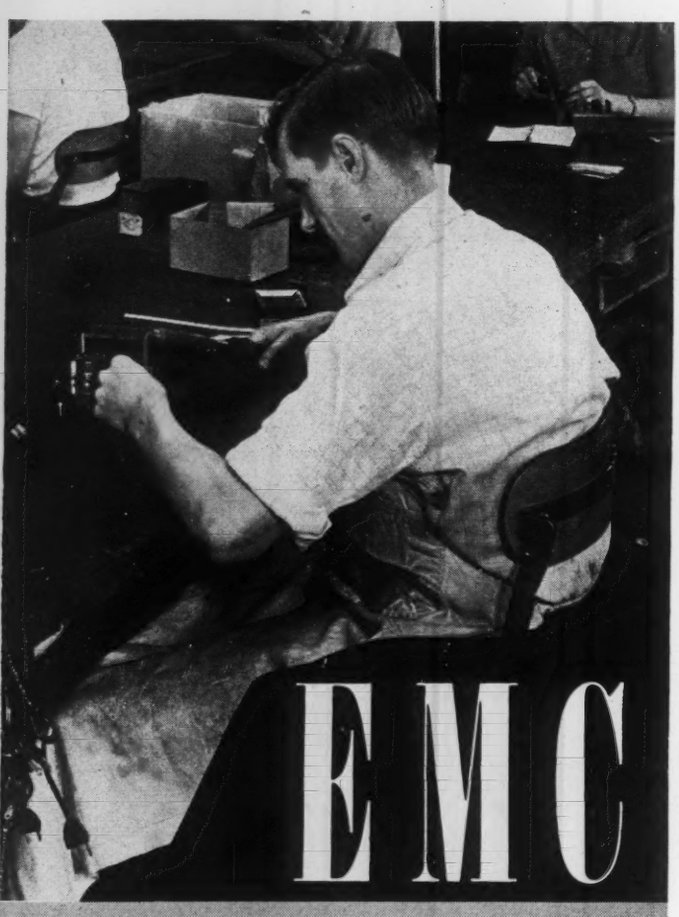


Eternal vigilance against explosive gases and the single spark that will set them off is kept by mines, paint factories, chemical plants and hundreds of ordinary manufacturers.

This Welco Motor transmits power from such a tightly sealed housing that the Bureau of Mines has approved its use in gaseous areas. The totally enclosed explosion-proof motor is typical of specially designed Welco Torque Motors. Performance features are built to specification.

We'll build the special torque motor that answers your out-of-the-ordinary powering problem.

**THE B. A. WESCHE ELECTRIC CO.**
**1622-15 VINE ST. CINCINNATI 10, OHIO**




**A HALLMARK OF PRECISION** that inspires the E-M-C craftsman to vigilantly maintain his highest standards of workmanship in building the finest and most dependable of Fractional Horsepower Motors.*

With a vast accumulation of orders awaiting production, E-M-C is adhering to the fairest policy by supplying the needs of our established customers first. Hence *quality* will not be sacrificed to attain *quantity* production.

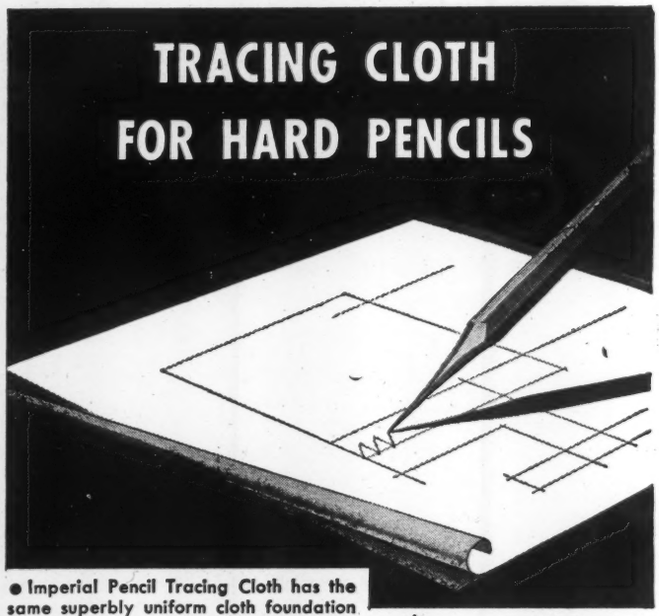
* One-Fifteenth H.P. is Largest Motor We Manufacture.

TRADEMARK EMC REGISTERED

**ELECTRIC MOTOR CORPORATION**
Division Howard Industries, Inc.
Racine, Wisconsin

CUSTOM-BUILT FRACTIONAL H.P. MOTORS FOR ALL INDUSTRY

# TRACING CLOTH FOR HARD PENCILS



● Imperial Pencil Tracing Cloth has the same superbly uniform cloth foundation and transparency as the world famous Imperial Tracing Cloth. But it is distinguished by its special dull drawing surface, on which hard pencils can be used, giving clean, sharp, opaque, non-smudging lines.

Erasures are made easily, without damage. It gives sharp, contrasting prints of the finest lines. It resists the effects of time and wear, and does not become brittle or opaque.

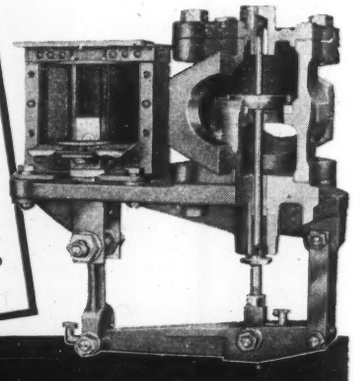
Imperial Pencil Tracing Cloth is right for ink drawings as well

**IMPERIAL PENCIL TRACING CLOTH**

SOLD BY LEADING STATIONERY AND DRAWING MATERIAL DEALERS EVERYWHERE

**Match it against your needs**

- Provides full flow instantly
- Direct acting—no pilot valve
- For differential pressures up to 150 lbs.
- For temperatures up to 365° F.



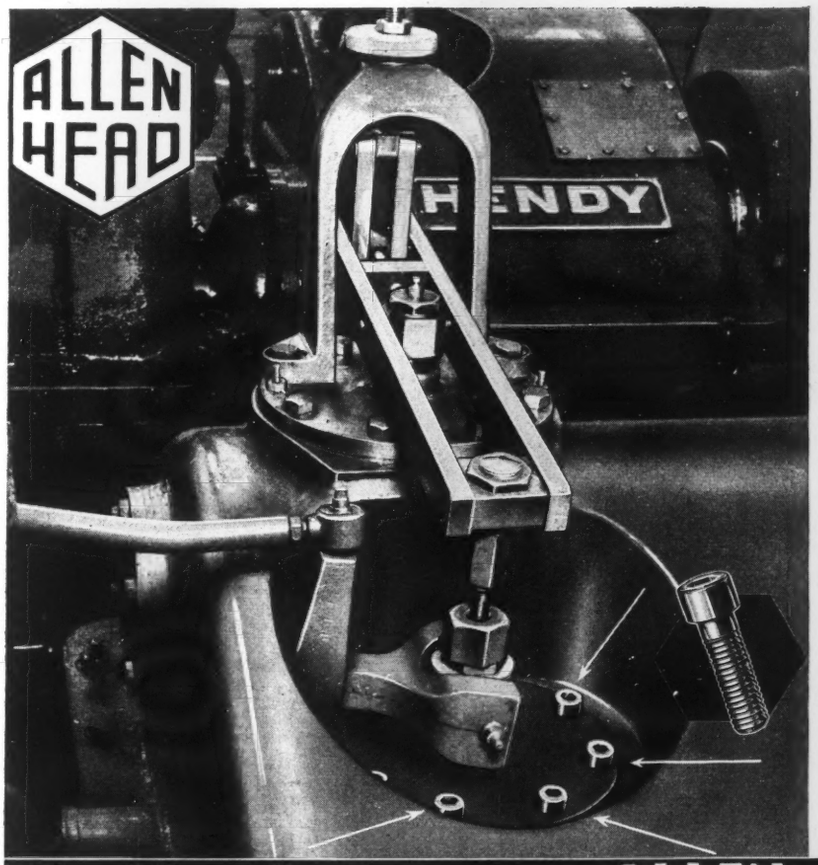
# NEW Automatic Valve

**Brings new advances — Serves new uses**

Now you *can* get a dependable, instant-opening automatic valve for practically all liquid level or flow control needs. This new Johnson Valve combines all the basic advantages of a direct-acting solenoid valve with the ability to operate under high differential pressures—up to 150 lbs. in some sizes. Its immediate response eliminates any time lag, or wiredrawing of valve or seat. The single seat construction dispenses with auxiliary pilot valves, minimizes danger of clogging. Can be used with hot and cold water, steam, oil, and other process liquids.

**New bulletin shows wide scope of the Johnson Solenoid Valve; ask for copy**

The Johnson Corporation
811 WOOD ST., THREE RIVERS, MICHIGAN




# ALLEN

## SOCKET HEAD CAP SCREWS

**— as used in the governor assembly of turbo-generator set, 500-kw. unit built by Joshua HENDY Iron Works, Sunnyvale, Calif.**

In the governor mechanism, in a special sense, the *controlling* factor is integrity of the assembly and DEPENDABILITY of its components. In this place of responsibility are ALLEN Socket Head Cap Screws, — and in *other* important places in the power unit.

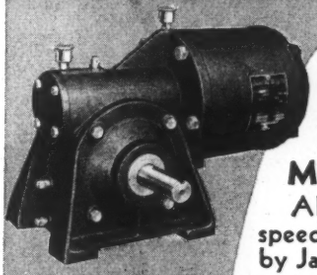
"Allens" have the HOLDING-POWER because they have the strength for powerful set-ups. Their strength is gained by *"pressur-forming"* of special-analysis *ALLENOY* steel, which makes the steel fibres conform to the shape of the screw head. In the perfectly-formed hex sockets, the keys bear evenly and equally on all surfaces. Threads also are *"pressur-formd"* to a high Class 3 fit, for high-friction hold in tapped hole.

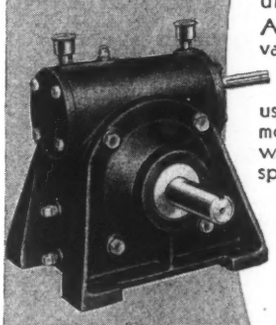
*Order of your local Industrial Distributor.*

**The Allen Mfg. Company ★ ALLEN ★ Hartford, Conn., U. S. A.**

Janette

## SPEED REDUCERS



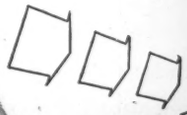


**ONE SOURCE . . .**
**Motorized or Motorless**

**All motors, brakes, gears and speed reducers are built completely by Janette . . .** there is no divided responsibility for their design, manufacture or successful operation.

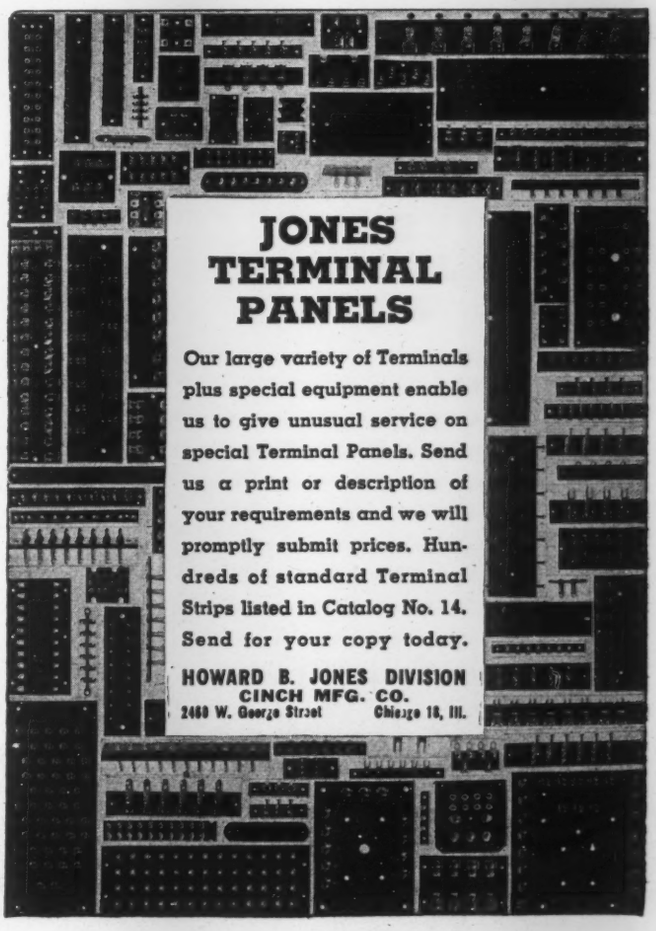
A right angle countershaft reducer is advantageous for most installations, because less space is necessary. The worm, or combination worm and planetary gears used in Janette reducers, make one of the most sturdy, compact gear drives available, when the power transmitted and ratio of speed reduction are considered.

If you want either motorized or motorless speed reducers that are attractive in appearance, easy to install and maintain, efficient, quiet and reliable, you will find these features in Janette machines.



1/30 to 7 1/2 H.P.
.08 to 447 R.P.M.

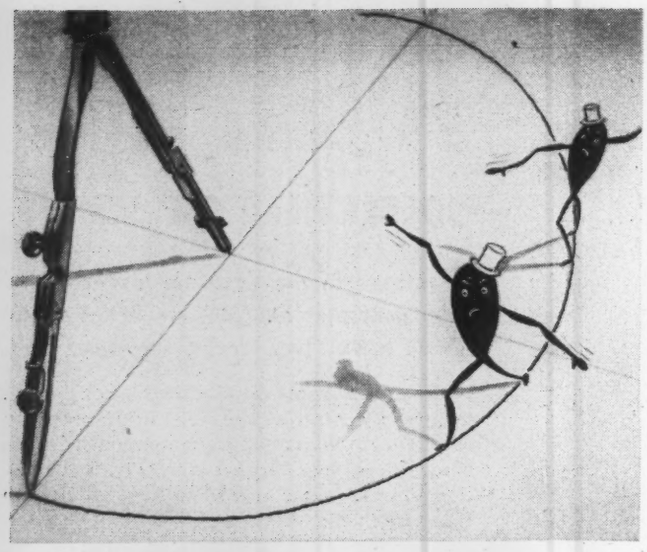
Janette Manufacturing Company
556 W. Monroe St. Chicago 6, Ill.



## JONES TERMINAL PANELS

**Our large variety of Terminals plus special equipment enable us to give unusual service on special Terminal Panels. Send us a print or description of your requirements and we will promptly submit prices. Hundreds of standard Terminal Strips listed in Catalog No. 14. Send for your copy today.**

**HOWARD B. JONES DIVISION**
**CINCH MFG. CO.**
2460 W. George Street Chicago 18, Ill.



## The Case of the NERVOUS PERIPHERY

● The tracer had to erase a couple of times. It happens to the best of us. And when he re-inked, his periphery was definitely on the "nervous" side. Next time he'll use Arkwright.

Erasures mean little to Arkwright tracing cloth. It can take erasure after erasure without wearing through, and it re-inks without line-feathering . . . ever!

See for yourself how much better Arkwright is. Send for free working samples. Arkwright is sold by leading drawing material dealers everywhere. Arkwright Finishing Company, Providence, R. I.

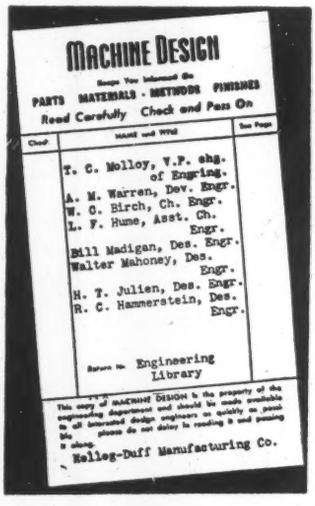
**All Arkwright Tracing Cloths have these 6 important advantages**

1 *Erasures re-ink without "feathering"*
2 *Prints are always sharp and clean*
3 *Tracings never discolor or become brittle*
4 *No surface oils, soaps or waxes to dry out*
5 *No pinholes or thick threads*
6 *Mechanical processing creates permanent transparency*

**Arkwright**
**TRACING CLOTHS**
AMERICA'S STANDARD FOR OVER 25 YEARS

# *Routing Slips*

**MAKE MACHINE DESIGN AVAILABLE TO ADDITIONAL DESIGN ENGINEERS**




● **Hundreds of engineering departments are using routing slips to make MACHINE DESIGN systematically available to their design engineers.**

**If you would like a year's supply send us the names and titles of readers in order of routing and we will prepare them and send them to you with our compliments.**

**These convenient slips are gummed on the back so that they can readily be affixed to the front cover of MACHINE DESIGN when it arrives each month.**

***For Your FREE Supply, Write:***

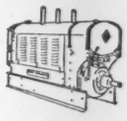
**MACHINE DESIGN**
***Reader's Service Department***
**PENTON BUILDING CLEVELAND 13, OHIO**

# A-C ENGINES Give Log Peelers "STAYING" POWER

An Allis-Chalmers W-25 engine provides reliable, low-cost power for this log peeler manufactured by the Nekoosa Foundry and Machine Works, Inc., Nekoosa, Wis.

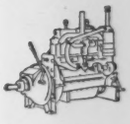
Machines for peeling bark from logs must have power that *hangs on*, even when logs are oversize or crooked. The manufacturer of Nekoosa wood peeling machines uses Allis-Chalmers Power Units because they are high in torque, cling to overloads like steam power. Flying bark or dirt doesn't bother them either, because of the generous-size air cleaners and oil filters. These engines stay on the job month after month, where a shut-down usually means costly loss of time and production.

Investigate economical Allis-Chalmers Power Units for your own products. Available with accessories to fit various applications. Choice of fuels. Nation-wide service facilities. Our power engineers will gladly help select the correct unit to fill your requirements.



ENCLOSED

**POWER UNITS Five Sizes**



OPEN STYLE

| | | |
|---|---|---|
| Model B-15 | 4 Cyl., | 24 Max. B.HP. at 1500 R.P.M. |
| Model W-25 | 4 Cyl., | 31.5 Max. B.HP. at 1300 R.P.M. |
| Model U-40 | 4 Cyl., | 45 Max. B.HP. at 1200 R.P.M. |
| Model E-60 | 4 Cyl., | 74 Max. B.HP. at 1050 R.P.M. |
| Model L-90 | 6 Cyl., | 110 Max. B.HP. at 1050 R.P.M. |

**ALLIS-CHALMERS**
TRACTOR DIVISION • MILWAUKEE 1, U. S. A.

*Extra Value...*

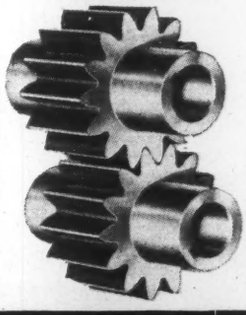
**GROUND... LAPPED... SHAVED GEARS**

- ★ SPUR
- ★ BEVEL
- ★ HELICAL
- ★ SPLINE
- ★ WORM
- ★ SPECIAL

Cincinnati GEARS, GOOD GEARS ONLY, have the built-in strength, stamina, accuracy . . . everything that long range performance must have to lower costs and increase profits.

To provide the maximum in gear efficiency CINCINNATI GEARS, where needed, are ground, shaved or lapped. We can shave from 1" to 24" pitch diameter. To eliminate distortion after hardening, high-speed precision gears can be ground to provide the required accuracy.

Look to Cincinnati GEARS, GOOD GEARS ONLY, for that extra value.



THE CINCINNATI GEAR COMPANY
*"Gears... Good Gears Only"*
Wooster Pike and Mariemont Ave. ★ Cincinnati 27, Ohio

CHROME ALLOY
STAINLESS STEEL
BRONZE
K-MONEL
ALUMINUM
CARBON STEEL
PLASTICS
GLASS
DRILLED
BALLS

*Hartford*
**PRECISION BALLS**

Precision balls for every industrial requirement. Made in many different materials. Send your specifications for recommendations from our Engineering Department.

**THE HARTFORD STEEL BALL CO.**
HARTFORD, CONN.

NEW YORK OFFICE
MURRAY HILL 6 1923

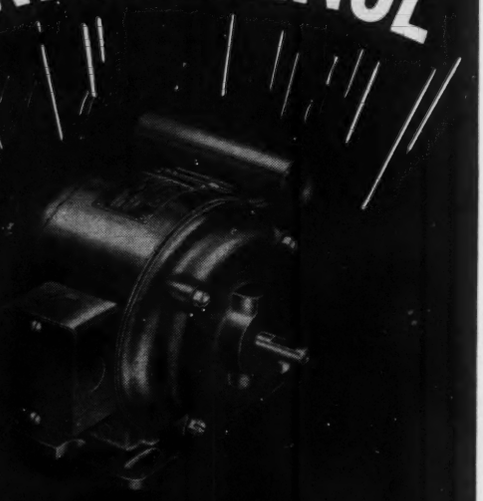
EXPORT OFFICE: NEW YORK
PHONE: PENNSYLVANIA 6 2078

CHICAGO OFFICE
HAYMARKET 8671

# OHIO MOTORS...

## Application Proved For

# TOP PERFORMANCE



The extra dependability and efficiency of Ohio "Application Proved" Motors is the result of meticulous attention to detail . . . from the design room through final inspection. More than 100 tests are applied to every Ohio Motor. To be sure that your product will deliver top performance, specify Ohio "Application Proved" Motors. Write today for a copy of our catalog.

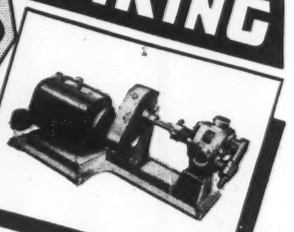
## THE OHIO ELECTRIC MFG. CO.

**Chester Bland, *President***

**5906 Maurice Ave. • Cleveland 4, Ohio**

You Are Looking at The **ROTARY PUMP** Most Folks Look For!

**VIKING**



And there's a reason . . .

It does the job because it is simple . . . just 2-moving parts—each self supported. It operates at low speed resulting in longer, trouble-free life. There are no gadgets, springs, timing gears, etc. to get out of order.

It's self-priming . . . moves the liquid without pulsation. Delivers against discharge pressures of 50-100-200-500 psi depending upon the application and construction.

See Our Catalog In SWEETS

Write today for folder 46SH.

**VIKING Pump COMPANY**
CEDAR FALLS, IOWA

The **FLEX V** TRADE-MARK

**Belt Fastener for A and B Belts of open end construction**

**Size No. A180 for A Belts**
**Size No. B214 for B Belts**

Flex V fasteners are made in two sizes for joining A and B V-belts of special open-end cross-woven fabric construction and on drives rated as light duty with a belt speed of not over 3000 feet per minute. The fasteners must not be used on heavy duty or high speed drives or for joining or repairing V-belts that were originally endless.

Flex V fasteners are easy to apply with the special applicator tool. The separable hinge joint makes for quick replacement of V-belts without dismantling shafting or machinery. Flex V fastened V-belts can also be run on V Flat Drives for there is no metal on the under side of the belt to contact the flat faced pulley.

Folder No. V-12 gives complete details on this Flex V fastener with list prices, special tools and application information. Your request will bring a copy.

***Order from your supply house***

**FLEXIBLE STEEL LACING CO.**
**4698 LEXINGTON ST., CHICAGO 44, ILLINOIS**

Also sole manufacturers of Alligator Steel Belt Lacing for flat transmission belts, Alligator V-belt Fasteners for V-belts and Flexco HD Belt Fasteners and Rip Plates for fastening and repairing conveyor belts.

ORDER YOUR COPY NOW...

# MECHANICAL SPRINGS

*by A. M. Wahl*

. . . eminent authority on springs and well-known for his development of the "WAHL CORRECTION FACTOR." He speaks from a wealth of practical experience obtained through his association with the Westinghouse Electric and Manufacturing Company

**$6.00* POSTPAID**

## CONTENTS

General Considerations in Spring Design—Helical Round-Wire Compression and Tension Springs—Open-Coiled Helical Springs with Large Deflection—Static and Fatigue Tests on Helical Springs and Spring Materials—Helical Springs Under Static Loading—Fatigue or Variable Loading of Helical Springs—Practical Selection and Design of Helical Compression Springs—Buckling of Helical Compression Springs—Helical Springs for Maximum Space Efficiency—Tension Springs—Square and Rectangular-Wire Compression Springs—Vibration and Surging of Helical Springs—Initially-Coned Disk (Belleville) Springs—Initially-Flat Disk Springs—Flat and Leaf Springs—Helical Torsion Springs—Spiral Springs—Ring Springs—Volute Springs—Rubber Springs and Mountings—Energy-Storage Capacity of Various Springs—Spring Materials.

BASED on original research and on practical applications, "Mechanical Springs" also includes results of investigations carried out under the direction of the American Society of Mechanical Engineers and the War Engineering Board Spring Committee of the Society of Automotive Engineers.

Fundamental principles and recent developments are presented so that springs can be designed to perform more satisfactorily than if "rule of thumb" methods were employed—saving both time and materials. Being important components of modern machines and devices, springs should be designed with care, especially if fatigue or repeated loading is involved. The information covered puts design on a rational basis. Convenient charts and tables aid quick selection. A glance at the contents will convince you of the comprehensive scope of this book.

**TEN DAYS FREE EXAMINATION**

If for any reason "Mechanical Springs" is not exactly what you need, it may be returned within ten days after receipt.

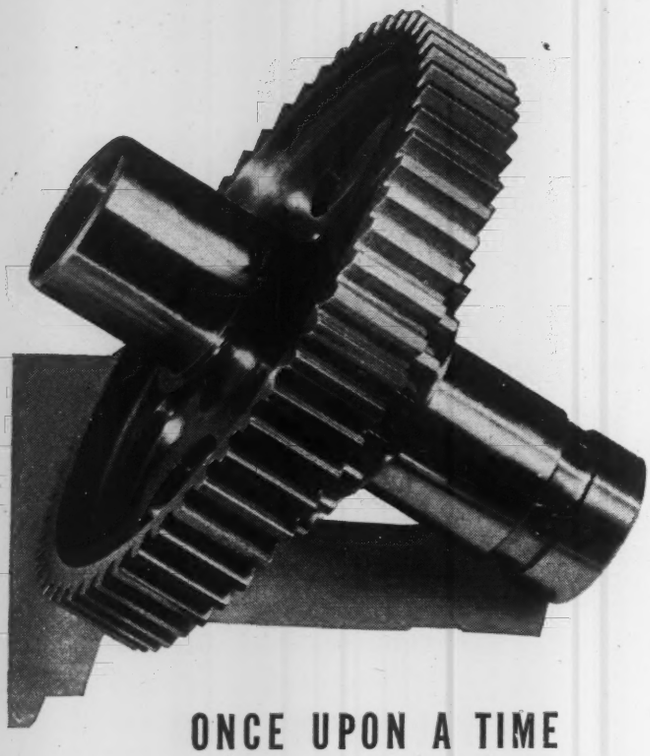
## MACHINE DESIGN

*Book Department*

**Penton Building** **Cleveland 13, Ohio**

*** Orders for delivery in Ohio, 18c additional for state sales tax. Postage will be prepaid if payment accompanies order, otherwise postal charges will be added.**

**ORDER YOUR COPY TODAY!**



ONCE UPON A TIME
THERE WAS A GEAR

. . . not just another ordinary "cog"

. . . this gear had exceptionally close tolerances necessitated by extreme high speeds of the end-product.

As you can imagine, it was kicked around a bit, that is, until the P. A. sent the specs to IGW.

With IGW's specialized facilities and skilled craftsmen, it became just another gear . . . just another quality job taken in stride.

Indiana GEARS
GEARS • CAMS • INTRICATE AND PRECISE MACHINE PARTS
INDIANA GEAR WORKS • INDIANAPOLIS 7, IND.

# ENGINEERS
## AVAILABLE OR WANTED

**AVAILABLE:** Positions for three top flight machine tool designing engineers having initiative, originality, creative ability, supervisory qualities and much experience in the designing of heavy machine tools. These positions, if ability is proven, will in a short time definitely lead to supervisory positions. Mechanical engineers degree preferable, but not necessary. Top salary. Reply is confidential. Address Box 538, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

♦

**AVAILABLE:** Manufacturers' representative. Engineering Executive widely experienced in automotive design and associated problems, and very well known to the trade, desires to represent several reputable manufacturers in the East with offices in Philadelphia, Pennsylvania. Address Box 539, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

♦

**AVAILABLE:** Engineering executive. Automotive executive engineer widely and expertly experienced in the design and conception of trucks, buses, passenger cars, engines and transmissions, is available to assume charge of engineering or act as an executive assistant. Inventive, fast and thoroughly familiar with all phases of modern manufacturing, styling, etc. Desires Philadelphia location. Address Box 540, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

♦

**WANTED:** Mechanical engineer experienced in selling pumping machinery to become District Representative in charge of our New York office. Salary plus commission. Opportunity for excellent earnings to qualified man. Write giving full experience history. Confidential. Dean Hill Pump Company, 4000 East 16th Street, Indianapolis 7, Indiana.

♦

**WANTED: Experienced design engineer to design precision machines and equipment for rebuilding internal combustion engines, principally automotive. Excellent opportunity promising permanency and advancement offered by progressive, old-line company in middlewest. Write today giving complete personnel history, enclosing recent photograph or snapshot. All information confidential. Address Box 531, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.**

♦

**WANTED:** Here's a rare creative opportunity in a smaller Pennsylvania town for a design engineer to refine and improve established machine tools. Small concern, over 60 years old, needs experienced machine tool designer for position of assistant chief engineer. The man our general manager appoints must be experienced in hydraulically controlled heavy machine tools . . . familiar with job shop operations. Experience with horizontal boring machine tools and special purpose facing machines is desirable. Preferably above middle-age, our new assistant must be a pace-setter . . . creative minded . . . able to think and act fast. If this is your opportunity, write today to Box 537, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

# PRECISION SCREW MACHINE PRODUCTS

U. S. AUTOMATIC

BAR STOCK CAPACITY
3/64" to 5 1/2"

Each day more and more management executives are finding that precision made screw machine parts made by U. S. are the right answer to their parts problems. Precision parts at the right price are your greatest opportunity for reducing costs and increasing profits. Send us your prints today.

PLATING • HEAT TREATING • GRINDING

## U • S • AUTOMATIC CORPORATION

*Screw Machine Products* AMHERST, OHIO

CHICAGO • DETROIT • INDIANAPOLIS • NEW YORK • PHILADELPHIA • PITTSBURGH

## DRILL JIG BUSHINGS

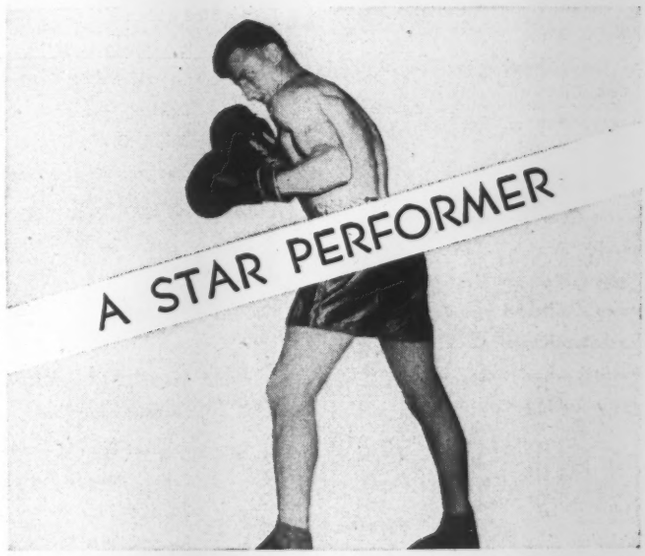
Accurate

Interchangeable

Concentric

Acme Industrial Company
211 N. LAFLIN ST.
CHICAGO 7, ILLINOIS

WRITE FOR FREE CATALOG!




*Elliott's* LIN-O-BLU *Paper*

NONE LIKE IT . . . FOR DIRECT BLUE LINE PRINTS

★ No. 11 *Fine Lines*

Elliott's LIN-O-BLU Ammonia developed paper should be used by you. IT is a STAR PERFORMER everytime. Available in thin, medium or heavy weights.

WRITE FOR FREE SAMPLES, ADDRESS DEPT. V-5

B. K. ELLIOTT CO.

MANUFACTURERS OF REPRODUCTION PAPERS

PITTSBURGH — DETROIT — CLEVELAND

# ADVERTISING INDEX


A

Acme Industrial Co. ..... 287
Adel Precision Products Corp. ..... 210
Allegheny-Ludlum Steel Corp. ..... 33
Allen Manufacturing Co., The ..... 281
Allis-Chalmers Manufacturing Co. ..... Inside Front Cover, 35, 283
Allis, Louis, Co., The ..... 67, 68
Aluminum Company of America ..... 15
Aluminum Industries, Inc. ..... 69
Aluminum Research Institute ..... 214
American Brass Co., The ..... 225, 226
American Felt Co. ..... 252
American Metal Hose, Branch The American Brass Co. ..... 29
American Pulley Co., The ..... 243
American Roller Bearing Co. ..... 256
American Screw Co. ..... 64
Arkwright Finishing Co. ..... 282
Armstrong Cork Co. ..... 71
Arrow-Hart & Hegeman Electric Co., The . 55

B

Bakelite Corp. ..... 14
Baldwin-Duckworth Division of Chain Belt Co. ..... 18, 19
Barnes, Wallace, Co. ..... 44
Bodine Electric Co. ..... 1
Bohn Aluminum & Brass Corp. ..... 230
Boston Gear Works, Inc. ..... 56, 57
Brandt, Charles T., Inc. ..... 10
Briggs & Stratton Corp. ..... 248
Brown & Sharpe Manufacturing Co. .... 191
Brown-Brockmeyer Co., The ..... 49
Bruning, Charles Co., Inc. ..... 17
Bundy Tubing Co. ..... 96

C

Carboloy Co., Inc. ..... 206
Carnegie-Illinois Steel Corp. ..... 21
Carpenter Steel Co., The ..... 204
Cash, A. W., Valve Manufacturing Corp. 271
Century Electric Co. ..... 32
Chicago Rawhide Manufacturing Co. ..2, 179
Chicago Screw Co., The ..... 194
Chiksan Co. ..... 256
Cincinnati Gear Co., The ..... 283
Clark Controller Co., The ..... 229
Cleveland Welding Co., The ..... 22
Climax Molybdenum Co. ..... 183
Columbia Steel Co. ..... 21
Commercial Shearing & Stamping Co., The 274
Continental-Diamond Fibre Co. ..... 60
Crane Co. ..... 20
Cuno Engineering Corp. ..... 30
Cutler-Hammer, Inc. ..... Back Cover

D

Danly Machine Specialties, Inc. ..... 233
Dayton Rubber Manufacturing Co., The 88, 89
De Laval Steam Turbine Co. ..... 268
Detroit Bevel Gear Co. ..... 272
Diamond Chain Co., Inc. ..... 40
DoAll Company, The ..... 79
Dodge Manufacturing Corp. ..... 90
Dodge Steel Co. ..... 51
Dow Chemical Co., The ..... 169
Dow Corning Corp. ..... 190
du Pont de Nemours, E. I. & Co., Inc. .. 193

E

Eastman Kodak Co. ..... 189
Eberhardt-Denver Co. ..... 262
Elastic Stop Nut Corp. of America ..... 66
Electric Indicator Co. ..... 252
Electric Motor Corp. ..... 280
Electrol, Inc. ..... 224
Elliott, B. K., Co. ..... 287
Emerson Electric Mfg. Co., The ..... 200
Erie Bolt & Nut Co. ..... 232
Ex-Cell-O Corp. ..... 54

F

Fafnir Bearing Co., The ..... 227
Farval Corp., The ..... 59
Federal Electric Products Co. ..... 181
Federal-Mogul Corp. ..... 254
Fellows Gear Shaper Co., The ..... 75
Ferry Cap & Set Screw Co., The ..... 4
Flexible Steel Lacing Co. ..... 284
Formsprag Co. ..... 264
Foote, Brad, Gear Works ..... 274
Foote Bros. Gear & Machine Corp. ..... 28
Fulton Sylphon Co., The ..... 37

G

Gast Manufacturing Corp. ..... 240
Gear Specialties ..... 13
General Electric Co., Nela Specialty Div. 78
Gerotor May Corp. ..... 212
Gisholt Machine Co. ..... 12
Goodrich, B. F., Chemical Co. (Hycar) .. 39
Goodrich, B. F., Co. ..... 271
Graham Transmissions, Inc. ..... 5
Greer Hydraulics, Inc. ..... 195
Grinnell Co., Inc. ..... 209

H

Hannifin Manufacturing Co. ..... 36
Hansen Manufacturing Co., The ..... 81
Hanson-Van Winkle-Munning Co. ..... 86
Harper, H. M., Co., The ..... 246
Hartford Steel Ball Co., The ..... 283
Haydon Manufacturing Co., Inc. ..... 270
Heim Co., The ..... 255
Hilliard Corp., The ..... 243
Holo-Krome Screw Corp., The ..... 220
Hoover Ball & Bearing Co. ..... 244
Houghton, E. F., & Co. ..... 171
Hyatt Bearings Division, General Motors Corp. ..... 205
Hydro-Power, Inc. ..... 221

I

Imperial Pencil Tracing Cloth Co. ..... 280
Indiana Gear Works ..... 286
Industrial Gear Manufacturing Co. ..... 271
Industrial Machine Works, Inc. ..... 245
International Nickel Co., Inc., The ... 23, 217

J

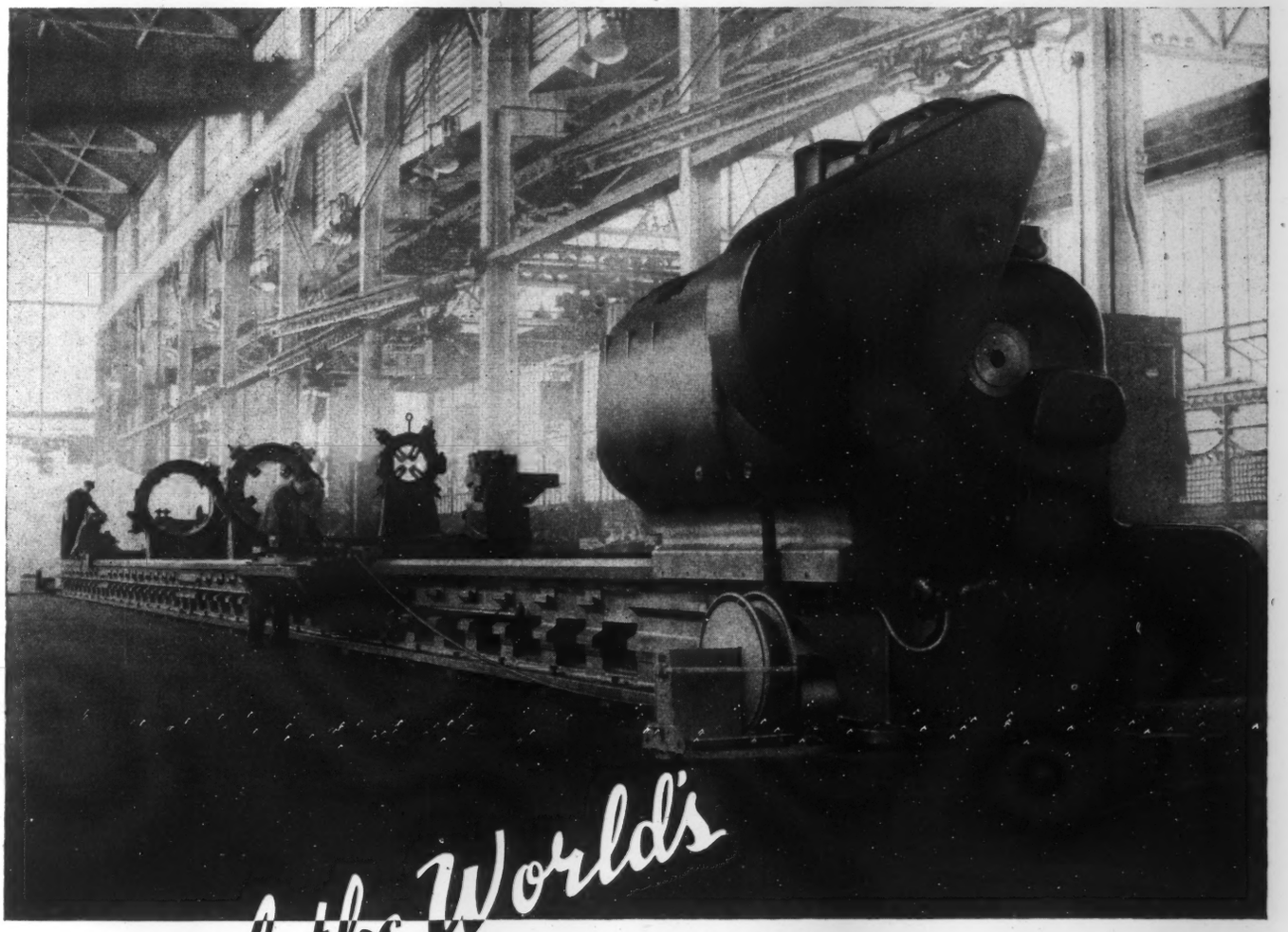
James, D. O., Manufacturing Co. ..... 100
Janette Manufacturing Co. ..... 281
Johns-Manville Corp. ..... 173
Johnson Bronze Co. ..... 167
Johnson, Carlyle, Machine Co., The ..... 38
Johnson Corp., The ..... 280
Jones & Laughlin Steel Corp. ..... 175
Jones, Howard B., Division ..... 281
Jones, W. A., Foundry & Machine Co. .. 228

K

Keuffel & Esser Co. ..... 24
Kinney Manufacturing Co. ..... 272

L

Lincoln Electric Co., The ..... 187
Linde Air Products Co., The ..... 238



*Manufactured by Wickes Bros., Saginaw, Mich.*

*One of the World's*

# LARGEST lathes

**This giant lathe 114 feet long is equipped with 74 M-R-C Ball Bearings in the most vital positions.**

# M-R-C BALL BEARINGS

**MARLIN - ROCKWELL CORPORATION**

Executive Offices: JAMESTOWN, N. Y.

# ADVERTISING INDEX


Lindsay Corp., The ..... 82
Linear, Inc. ..... 53
Link-Belt Co. ..... 11
Lisle Corp. ..... 257
Littleford Bros., Inc. ..... 279
Lord Manufacturing Co. ..... 83

Mc

McGill Manufacturing Co., Inc. ..... 50

M

Mahon, R. C., Co., The ..... 215
Mall Tool Co. ..... 273
Marco Co., Inc. ..... 235
Marlin-Rockwell Corp. ..... 289
Marsh, Jas. P., Corp. ..... 219
Marvel Engineering Co. ..... 272
Master Electric Co. ..... Inside Back Cover
Mechanics Universal Joint Division, Borg-Warner Corp. ..... 266
Michigan Tool Co. ..... 185
Micro Switch Corp. ..... 42, 43
Milford Rivet & Machine Co., The ..... 269
Miniature Precision Bearings, Inc. ..... 266
Moccasin Bushing Co. ..... 262
Moraine Products, Division of General Motors Corp. ..... 65
Morse Chain Co. ..... 97

N

National Acme Co., The ..... 94
National Bearing Division, American Brake Shoe Co. ..... 258
National Lock Washer Co., The ..... 218
National Motor Bearing Co., Inc. ... 62, 63
Nelson Sales Corp. ..... 249
New Departure Division of General Motors Corp. ..... 6
Norgren, C. A., Co. ..... 253
Norma-Hoffmann Bearings Corp. ..... 16

O

Ohio Crankshaft Co., The ..... 47
Ohio Electric Manufacturing Co. ..... 284
Ohio Rubber Co., The ..... 213
Oilgear Company, The ..... 9
Onan, D. W., & Sons, Inc. ..... 53
Owens-Corning Fiberglas Corp. ..... 46
Ozalid Division of Aniline & Film Corp. ... 31

P

Parker-Kalon Corp. ..... 77
Phillips Screw Manufacturers ..... 292
Phosphor Bronze Smelting Co., The ..... 246
Pope Machinery Corp. ..... 93
Porter, H. K., Co., Inc. ..... 192
Propulsion Engine Corp. ..... 269

R

R-B-M Division Essex Wire Corp. ..... 231
Redmond Co., Inc. ..... 195
Reliable Spring & Wire Forms Co., The ... 263
Reliance Electric & Engineering Co. ..... 25
Revere Copper & Brass, Inc. ..... 207, 208
Reynolds Metals Co. ..... 203
Rhode Island Tool Co. ..... 262
Riverside Metal Co., The ..... 87
Robbins & Myers, Inc. ..... 51
Rockford Clutch Division Borg-Warner Corp. ..... 269
Rollway Bearing Co., Inc. ..... 236
Ross Operating Valve Co. ..... 76

S

Schatz Manufacturing Co., The ..... 202
Scovill Manufacturing Co. ..... 239
Shakeproof, Inc. ..... 201
Shenango-Penn Mold Co. ..... 41
Smith, Winfield H., Corp. ..... 92
Speer Carbon Co. ..... 52
Split Ballbearing Corp. ..... 270
Standard Locknut & Lockwasher, Inc. ..... 274
Standard Pressed Steel Co. ..... 70
Steel Founders' Society ..... 222
Steel Improvement & Forge Co., The ..... 85
Stephens-Adamson Manufacturing Co. ... 241
Sterling Electric Motors, Inc. ..... 237
Strom Steel Ball Co. ..... 275
Struthers-Dunn, Inc. ..... 8
Sundstrand Machine Tool Co. ..... 45
Superdraulic Corp. ..... 95
Superior Carbon Products, Inc. ..... 264
Superior Tube Co. ..... 242
Surface Checking Gage Co. ..... 273
Synthane Corp. ..... 197, 198

T

Tennessee Coal, Iron & Railroad Co. ..... 21
Thompson-Bremer & Co. ..... 84
Timken Roller Bearing Co., The ..... 223
Tinnerman Products, Inc. ..... 266
Torrington Co., The ..... 211
Trico Fuse Manufacturing Co. ..... 279
Trumbull Electric Manufacturing Co., The ..... 215
Tube Turns, Inc. ..... 261
Tuthill Pump Co. ..... 275
Twin Disc Clutch Co. ..... 291

U

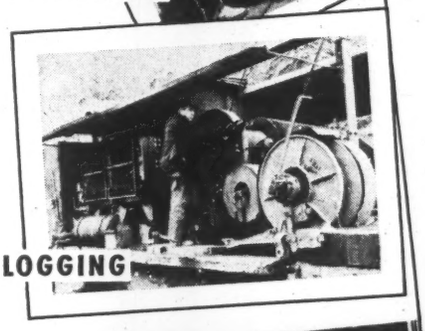
Union Carbide & Carbon Corp. ..... 14, 233
United Screw & Bolt Corp. ..... 177
United States Gauge Division of American Machine & Metals, Inc. ..... 34
United States Graphite Co., The ... 26, 27, 250
United States Radium Corp. ..... 247
United States Steel Corp. ..... 21
United States Steel Export Co. ..... 21
United States Steel Supply Co. ..... 21
U. S. Automatic Corp. ..... 287

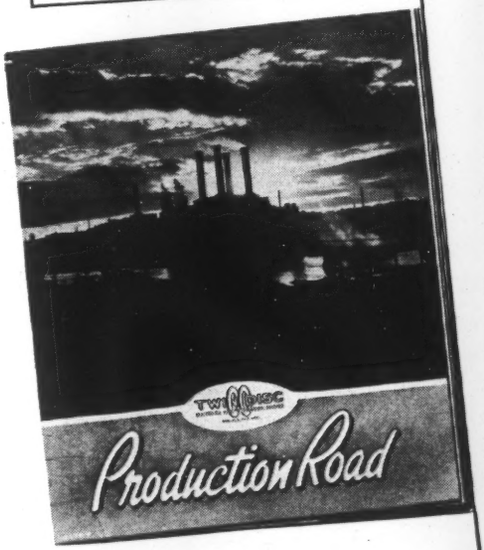
V

Valley Electric Corp. ..... 273
Valvair Corp. ..... 275
Veeder-Root, Inc. ..... 199
Vickers, Inc. ..... 99
Viking Pump Co. ..... 284

W

Wagner Electric Corp. ..... 234
Waldes Kohinoor, Inc. ..... 72, 73
War Assets Administration ..... 263, 265
Ward Leonard Electric Co. ..... 74
Wesche, B. A., Electric Co., The ..... 279
Western Felt Works ..... 48
Whitney Chain & Manufacturing Co., The ..... 251
Wisconsin Motor Corp. ..... 270
Wisconsin Pharmacal Co. ..... 268
Witte Engine Works ..... 264
Wolverine Tube Division Calumet & Hecla Consolidated Copper Co. ..... 80
Worthington Pump & Machinery Corp. ... 91



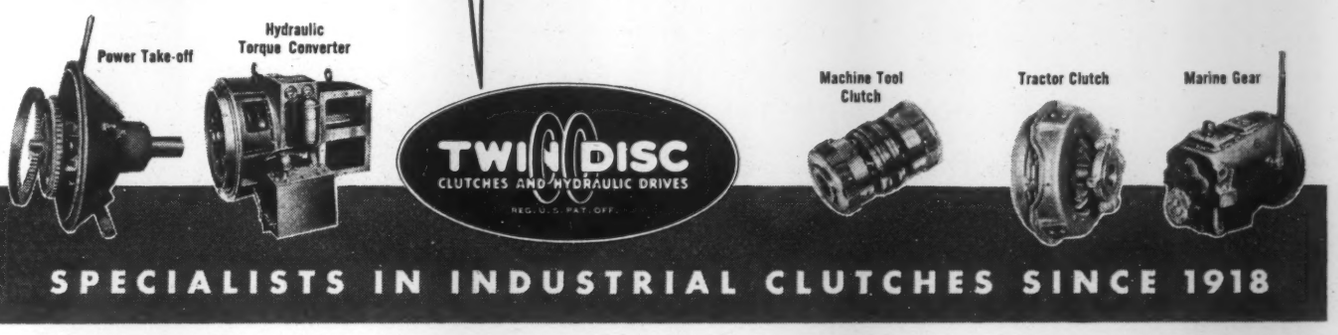




# *In Your Customers' Interests*

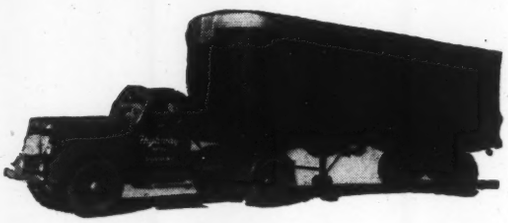
The "Manufacturers' Issue" of PRODUCTION ROAD illustrates how the constant study of all types of power transmission problems . . . from both the builder and user points of view . . . has given Twin Disc Clutch Company engineers the know-how necessary to design and build clutches and hydraulic drives that you can deliver to your customers with the utmost confidence.

Twenty-nine years of experience . . . of painstaking laboratory and on-the-job tests . . . have put Twin Disc Clutches and Hydraulic Drives ahead of the field in transmitting industrial power. Regardless of how your equipment is used, if a Twin Disc unit can be applied, its installation will assure the man who buys your product a minimum of power transmission worries.

Write the Twin Disc Clutch Company, Racine, Wisconsin, for the "Manufacturers' Issue" of PRODUCTION ROAD which describes how the full line of Twin Disc Clutches and Hydraulic Drives are incorporated in powered equipment in all industries. TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).



# HIGHWAY TRAILER CO. gets assembly into high



*Independent investigator finds Phillips Screws cut driving time in half, stop costly driver slips, prevent accidents.*

*Fastening the roof trim with Phillips Screws instead of with bolts as formerly, which required a man inside and another outside the van. Now it's a one-man job, and in driving 38 Phillips Screws, he saves 15 minutes of the time he'd need to drive slotted screws.*

*'Way down by the floor and 'way up to the roof... both ways Phillips Screws end the troublesome, time-wasting necessity of eye-level driving of slotted screws.*

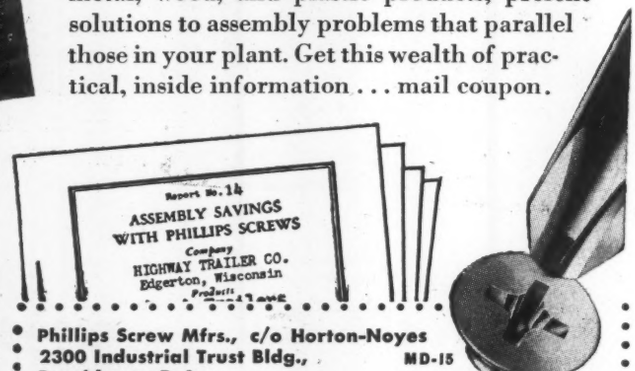
"WHEN YOU'RE DRIVING 552 self-tapping screws on a big assembly job like our closed-van trailer, the Phillips Recessed Head makes a tremendous difference," the chief engineer told a James O. Peck Co. investigator making another survey of assembly savings with Phillips Screws in key plants.

**"PHILLIPS SCREWS CUT DRIVING TIME IN HALF.** It takes four men just 13 minutes to power-drive all the Phillips Head Self-tapping Screws that fasten the big plywood panels which line our 26-foot trailer vans. Because the driver centers automatically in the Phillips Recessed Head, an assembler doesn't have to be at eye level with the screw, as when using slotted screws. That eliminated the need for platforms which used to cut down working space and slow down the assembly.

**"SAVE DRIVER SLIPS** that used to cost $2.50 to $3.50. These panels are fastened very near the edges. Before, when a bit slipped out of a slotted screw, the panel was usually split. Phillips Screws eliminated this cost completely.

**"EASIER ON MEN'S HANDS.** Our assemblers used to get hand cuts, often serious, when bits jumped out of slotted screws. That doesn't happen with Phillips Screws because the bit always centers snugly and stays."

**THIS AND OTHER ASSEMBLY STUDIES** covering metal, wood, and plastic products, present solutions to assembly problems that parallel those in your plant. Get this wealth of practical, inside information . . . mail coupon.




## PHILLIPS Recessed Head SCREWS

**Wood Screws • Machine Screws • Self-tapping Screws • Stove Bolts**

23 SOURCES

American Screw Co.
Central Screw Co.
Continental Screw Co.
Corbin Screw Div. of American Hdwe. Corp
The H. M. Harper Co.
International Screw Co.
Lamson & Sessions Co.
Milford Rivet and Machine Co.
Pheoll Manufacturing Co.
National Lock Co.
National Screw & Mfg. Co.
New England Screw Co.
Parker-Kalon Corporation
Pawtucket Screw Co.
Reading Screw Co.
Russell Burdsall & Ward Bolt & Nut Co.
Scovill Manufacturing Co.
Shakeproof Inc.
The Southington Hardware Mfg. Co.
The Steel Company of Canada, Ltd.
Sterling Bolt Co.
Stronghold Screw Products, Inc.
Wolverine Bolt Company

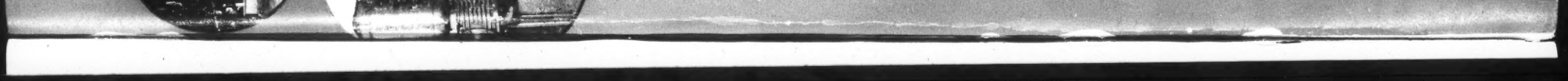
**Phillips Screw Mfrs., c/o Horton-Noyes**
**2300 Industrial Trust Bldg., MD-15**
**Providence, R. I.**

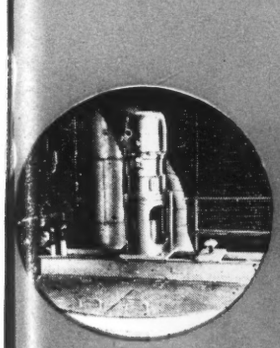
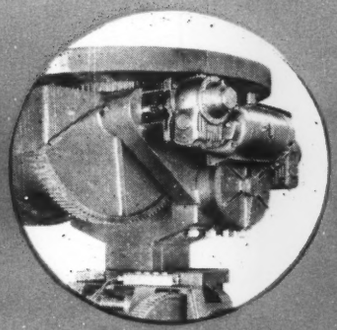
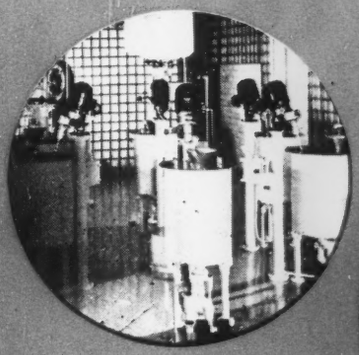
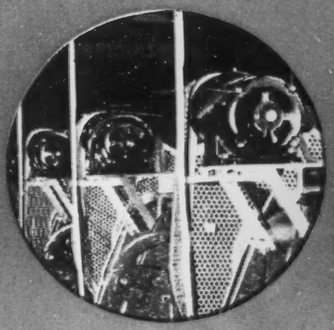
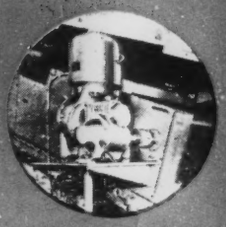
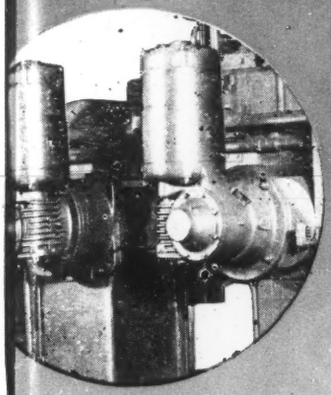
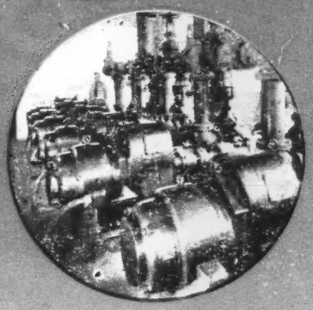
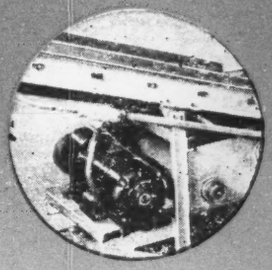
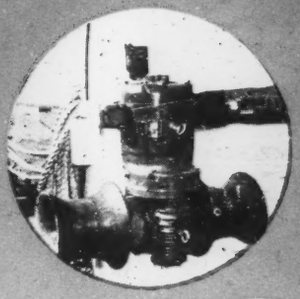
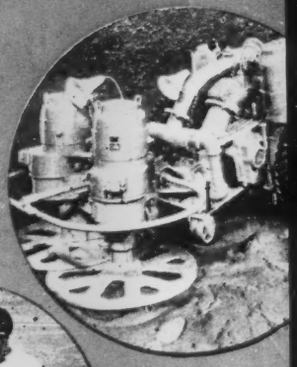
Send me reports on Assembly Savings with Phillips Screws.

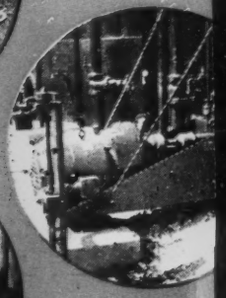
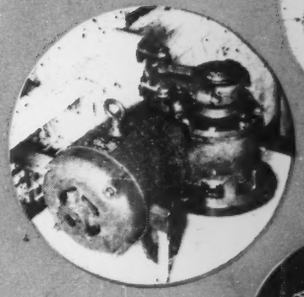
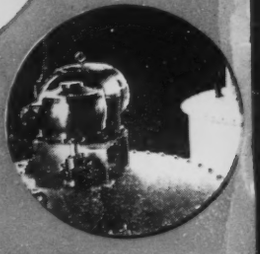
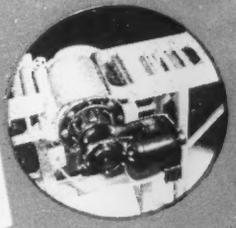
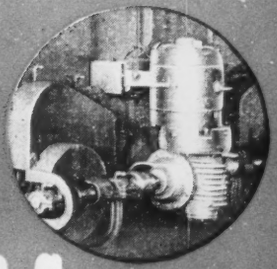
*Name* .....

*Company* .....

*Address* .....



# *the* RIGHT *horsepower*
# *the* RIGHT *shaft speed*
# *and* RIGHT *where you want it*

Don't put up any longer with make-shift assemblies when you can get the RIGHT horsepower, the RIGHT shaft speed, the RIGHT construction features, the RIGHT mounting . . . all combined into one compact power package.

Master Gearmotors, available in millions on millions of combinations of types and ratings, permit you to use a power drive on each job that's just right . . . a power drive that will add greatly to the compactness, appearance, and economy of each of your applications.

Use Master Gearmotors to increase the salability of your motor-driven products . . . improve the economy, safety, and productivity of your plant equipment. They're the horse sense way to use horsepower.

MASTER

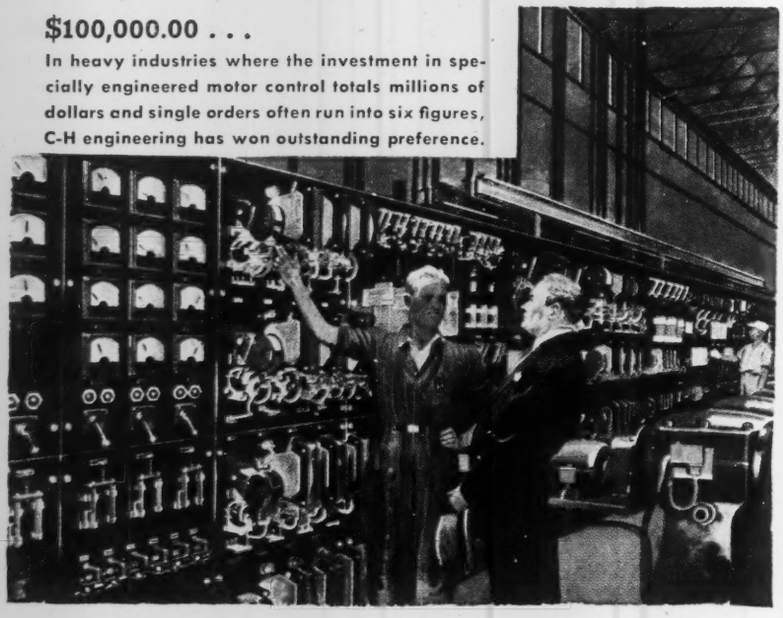
GEARMOTORS

THE MASTER ELECTRIC COMPANY • DAYTON 1, OHIO

# One standard of excellence

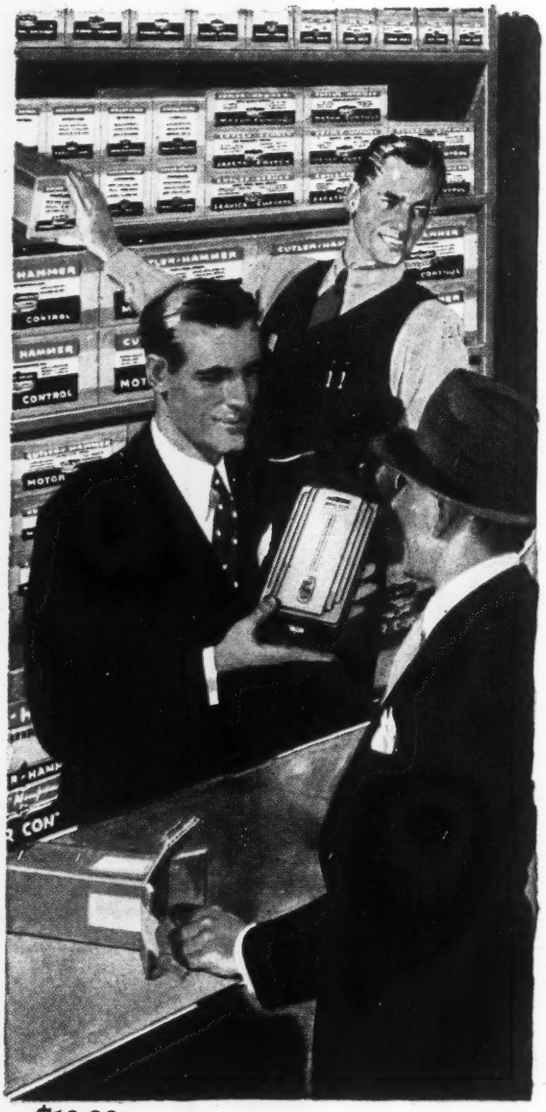
**$100,000.00 . . .**

**In heavy industries where the investment in specially engineered motor control totals millions of dollars and single orders often run into six figures, C-H engineering has won outstanding preference.**



**$1,000.00 . . .**

**In answer to the motor control problems of general industry, C-H engineers, the recognized control specialists, have consistently created standardized equipment of acknowledged superiority.**




**$10.00 . . .**

**The many exclusive engineering features of even the smallest units of Cutler-Hammer general purpose motor control and the performance records this equipment has established fully confirm its pedigree.**

Industry's needs in motor control equipment are as varied as the duties electric motors are called upon to perform. In some instances, scores of motors are interrelated in a highly complex, specially engineered project in which the motor control becomes the very brain of a giant production unit. In other instances, the motor functions are relatively simple and the control can be provided by standardized general purpose motor control available from the stocks of hundreds of conveniently located electrical wholesalers. In this field of widely varying requirements, however, one feature of motor control *must* remain absolutely fixed. That feature is *dependable* performance. No motor can be so small or its use so casual that reliable operation is unimportant. To this end Cutler-Hammer engineering has long recognized but one standard of excellence . . . the closest approach to faultless performance that ingenuity and conscientious craftsmanship can provide. CUTLER-HAMMER, Inc., 1310 St. Paul Avenue, Milwaukee 1, Wisconsin *Associate:* Canadian Cutler-Hammer, Ltd., Toronto.

CUTLER-HAMMER
MOTOR CONTROL
C-H